

Marine fish and invertebrate atlas: geographic distribution, population indices and environmental associations of marine species in the Scotian Shelf and Bay of Fundy derived from the annual Maritimes summer survey (1970-2020)

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MARINE FISH AND INVERTEBRATE ATLAS: GEOGRAPHIC DISTRIBUTION, POPULATION INDICES AND ENVIRONMENTAL ASSOCIATIONS OF MARINE SPECIES IN THE SCOTIAN SHELF AND BAY OF FUNDY DERIVED FROM THE ANNUAL MARITIMES SUMMER SURVEY (1970-2020)

by

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ABSTRACT

Ricard, D., Gomez, C., Emberley, J., Regnier-McKellar, C. and Martin, R. 2022. Marine fish and invertebrate atlas: geographic distribution, population indices and environmental associations of marine species in the Scotian Shelf and Bay of Fundy derived from the annual Maritimes summer survey (1970-2020). *Can. Tech. Rep. Fish. Aquat. Sci.* 3498: viii + 192 p.

The summer research vessel survey on the Scotian Shelf bioregion started in 1970 and was designed to measure the distribution and abundance of major commercial and non-commercial species. This report builds on previous work and former atlases by updating a comprehensive suite of indices to assess population status and environmental associations of 103 species. For each species, trends in geographic distribution and biomass were plotted. The spatial extent of distribution was plotted over time to gauge changes in the area occupied. The relationship between abundance or biomass and spatial extent reflected whether the species distribution expands when biomass increases. Length frequencies over time depicted any changes in mean size. The plots of condition over time revealed whether individual fish are fatter or thinner than their long term mean. Depth, temperature and salinity associations were estimated to gauge the range of suitable environmental parameters for each species. Finally, for each stratum, the slope describing how local density varies with regional abundance was estimated. The reproducible set of tools provided in this report constitutes a stepping stone to conduct other ecological analyses using the summer groundfish research vessel survey data by fostering reproducibility and transparency of ecological information collected and reported annually.

RÉSUMÉ

Ricard, D., Gomez, C., Emberley, J., Regnier-McKellar, C. and Martin, R. 2022. Marine fish and invertebrate atlas: geographic distribution, population indices and environmental associations of marine species in the Scotian Shelf and Bay of Fundy derived from the annual Maritimes summer survey (1970-2020). Can. Tech. Rep. Fish. Aquat. Sci. 3498: viii + 192 p.

Le relevé estival par navire de recherche dans la biorégion du plateau néo-écossais a débuté en 1970 et visait à mesurer la répartition et l'abondance des principales espèces commerciales et non commerciales. Ce rapport s'appuie sur des travaux antérieurs et d'anciens atlas en mettant à jour une série complète d'indices pour évaluer l'état de la population et les associations environnementales de 103 espèces. Pour chaque espèce, les tendances de la répartition géographique et de la biomasse ont été tracées. L'étendue spatiale de la distribution a été tracée au fil du temps pour évaluer les changements dans la zone occupée. La relation entre l'abondance ou la biomasse et l'étendue spatiale indique si la répartition des espèces s'étend lorsque la biomasse augmente. Les fréquences de longueur au fil du temps représentaient tout changement dans la taille moyenne. Les graphiques de condition au fil du temps ont révélé si les poissons sont plus gros ou plus minces que leur moyenne à long terme. Les associations de profondeur, de température et de salinité ont été estimées pour évaluer la gamme de paramètres environnementaux appropriés pour chaque espèce. Enfin, pour chaque strate, la pente décrivant comment la densité locale varie avec l'abondance régionale a été estimée. L'ensemble d'outils reproductibles fournis dans ce rapport constitue un tremplin pour effectuer d'autres analyses écologiques à l'aide des données du relevé d'été des navires de recherche sur les poissons de fond en favorisant la reproductibilité et la transparence des informations écologiques recueillies et présentées annuellement.

1 Introduction

The summer (July-August) groundfish research vessel survey on the Scotian Shelf and in the Bay of Fundy was started in 1970 by Fisheries and Oceans Canada Maritimes Region. The survey was originally designed to measure the distribution and abundance of major commercial fish species. Over time, information on non-commercial species was also collected. The annual groundfish survey provides the main source of fisheries-independent information for marine species in the region. This information is available through database storing the information collected during the annual survey and is routinely used to support stock assessments, to produce species status reports, and has been previously used to publish atlases of species distribution.

This document is an update of an earlier report (Ricard and Shackell 2013) that built on former atlases by updating a comprehensive suite of derived indices for 103 species to assess population status and, when feasible, environmental preferences. The information collected during the survey is stored in a relational database management system archived at Fisheries and Oceans Canada Maritimes Region which contains detailed information about the sampling locations and the associated catch. Tow-level survey data is also publicly available from the Ocean Biogeographic Information System (DFO 2016) and from the Open data portal supported by the federal government (DFO 2021). The present atlas builds upon the work done by Fisheries and Oceans colleagues from the northern Gulf of St. Lawrence (Bourdages and Ouellet 2012), southern Gulf of St. Lawrence (Benoît et al. 2003) and on earlier work in the Scotian Shelf (Simon and Comeau 1994; Horsman and Shackell 2009).

All the necessary components required to assemble the current document are made available in a Git repository (Ricard and Gomez 2022). This step is deemed necessary to facilitate updates and to foster collaboration on further analyses of the available survey data. All the computer code necessary to extract the data and to perform the analyses presented herein is available from the git repository. We hope that this step will help to reproduce, update, and, undoubtedly, correct the results presented in the current report.

The survey area covers three major Northwest Atlantic Fisheries Organization (NAFO) zones that divide the Scotian Shelf into the colder east 4V and 4W (strata 440-466) and warmer west 4X (strata 470-495). For each species, temporal trends in geographic distribution and, when possible, biomass are plotted. Some caution is required in interpreting the results obtained for several taxa due to low sample size, as explained later in the text. A full ecological interpretation of trends is beyond the scope of this report. Other documents stemming from peer-reviewed scientific processes under the auspices of the [Canadian Science Advisory Secretariat](#) (CSAS) provide further descriptions of spatio-temporal trends in different indicators, and place the information collected during the summer groundfish research vessel survey in a more focused context, see for example Clark and Emberley (2011).

2 Methods

2.1 Survey Description

The survey is conducted annually in July-August and covers the Scotian Shelf and the Bay of Fundy (Figure 1). It normally involves at least two separate trips on board an offshore fisheries vessel from the Canadian Coast Guard for a total duration of around 6 weeks at sea.

The fishing platform used (the vessel and the type of fishing gear) has changed a number of times since the onset of sampling activities (Clark and Emberley 2011). Comparative fishing experiments were conducted when those changes in survey platforms took place (Koeller and Smith 1983; Fanning 1984; Fanning 1985; Fowler and Showell 2009). The A.T. Cameron using a Yankee 36 trawl was the primary survey vessel from 1970 to 1981. The vessel that was then built to replace the A.T. Cameron to conduct trawl surveys (CCGS Alfred Needler) was not yet operational and the Lady Hammond was used to bridge the gap between the A.T. Cameron and the CCGS Alfred Needler. A change to the Western IIA trawl also took place after A.T. Cameron was retired. The CCGS Alfred Needler entered service for the 1983 summer survey using a Western IIA trawl. It has been the main survey platform since. The CCGS Alfred Needler suffered a fire in late August 2003 and was still not available to conduct the survey in 2004, so CCGS Teleost was used instead. In 2007, 2008 and 2018 the CCGS Alfred Needler was not available and the survey was conducted on the CCGS Teleost in 2007 and 2018, and on the CCGS Wilfred Templeman in 2008. The relevant details of the survey vessels (Maginley et al. 2014) and fishing trawls (Fanning 1985) used can be found in Table 1 and a timeline of the survey platforms can be found in Figure 2. In 2018, because of the unavailability of the CCGS Alfred Needler, only a partial survey coverage was achieved on CCGS Teleost, and most of the strata in NAFO Division 4VW were not sampled. As such, while the limited 2018 data are available, they are not used in the analyses present herein since estimates derived using the 2018 data will not be comparable to other years.

Table 1. Details about the vessels and trawls used over the lifetime of the summer survey.

Survey vessels		
Name	Measurements	Description
A.T. Cameron	Length: 53.0m Gross tonnage: 735 t	Main survey vessel from 1970 to 1981
Lady Hammond	Length: 58.0m Gross tonnage: 897 t	Vessel used in 1982 and 1983 to bridge between the A.T. Cameron and the CCGS Alfred Needler
CCGS Alfred Needler	Length: 50.3m Gross tonnage: 959 t	Main survey vessel since 1983
CCGS Wilfred Templeman	Length: 50.3m Gross tonnage: 959 t	Sister ship of CCGS Alfred Needler, used in 2008
CCGS Teleost	Length: 63.0m Gross tonnage: 2,405 t	Used in 2007 and 2018
Fishing trawls		
Name	Measurements	Description
Yankee 36	Wing spread: 10.7m Headline height: 2.74m	Used on the A.T. Cameron from 1970 to 1982
Western IIA	Wing spread: 12.5m Headline height: 4.6m	Used since 1983

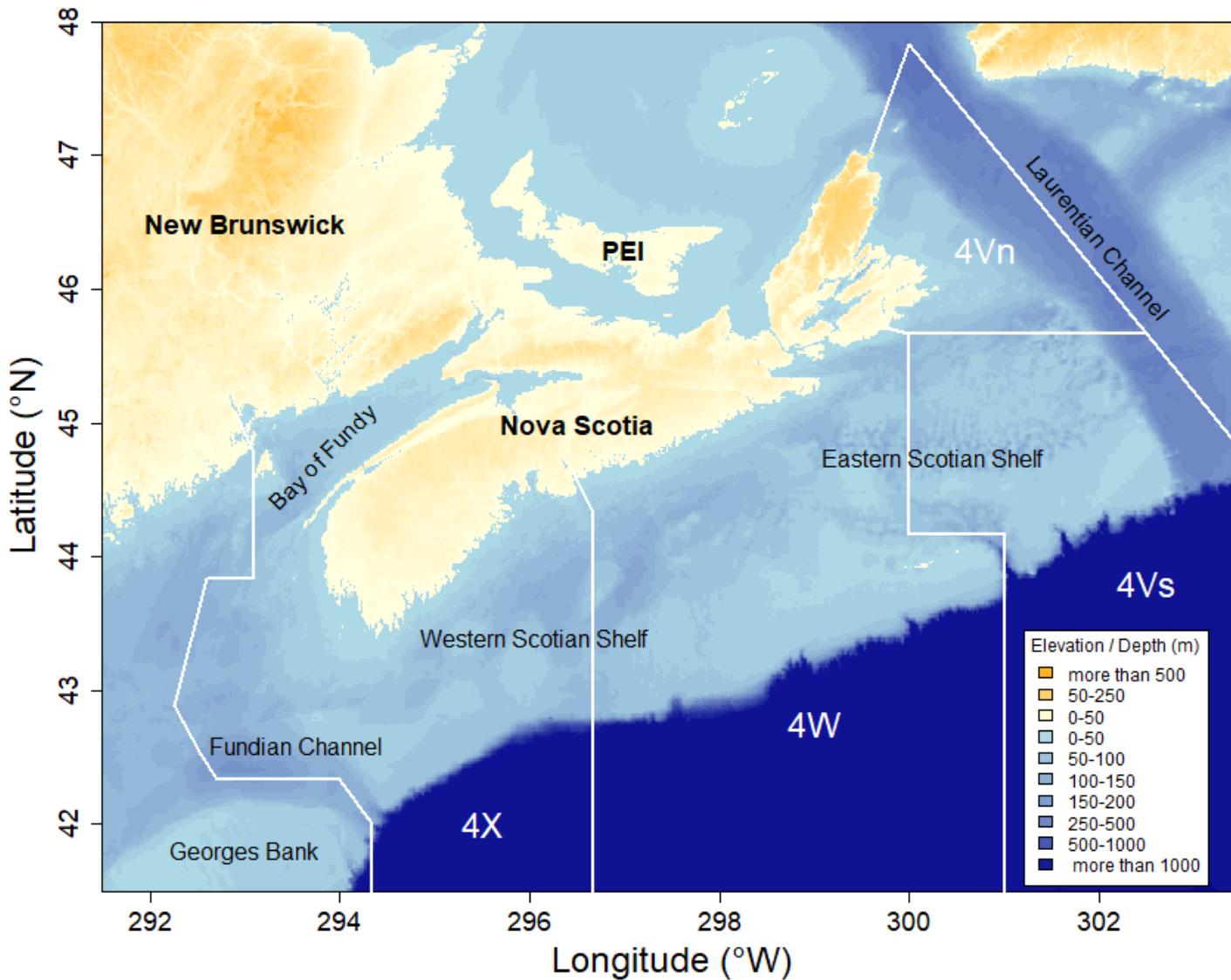


Figure 1. Map of the Scotian Shelf and Bay of Fundy where the DFO Maritimes summer survey takes place. The bathymetry presented here is the 15 arc-second gridded data set from the General Bathymetric Chart of the Oceans ([GEBCO](#)). Geographical locations of interest and the boundaries of relevant NAFO Divisions are also shown on the map.

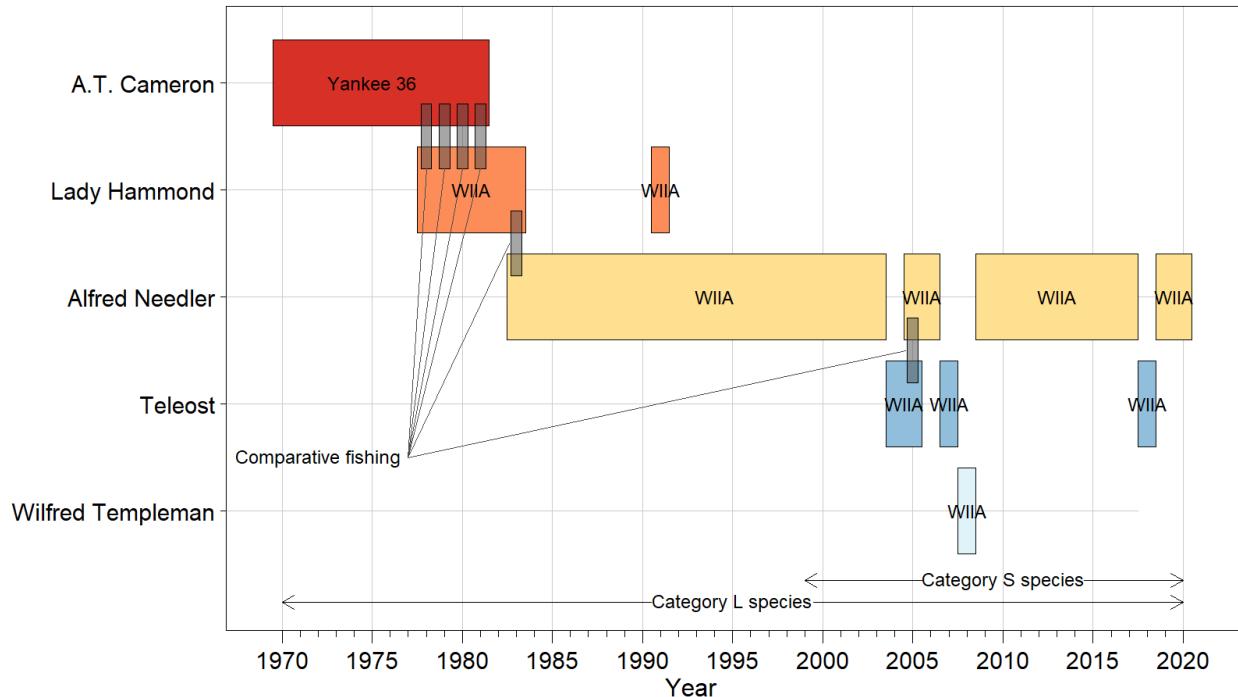


Figure 2. Timeline of survey platforms used in the Maritimes Region summer survey. The x axis denotes the timespan of the survey. The y axis identifies the vessel on which survey sets were conducted. The type of fishing gear deployed is overlaid on the rectangles representing the time window when each vessel was used (WIIA is the Western IIA trawl). Comparative fishing experiments are identified by gray polygons overlapping the survey platforms under comparison. The timespan where categories L and S species (see Section 2.3) were consistently recorded appears on the bottom of the figure.

2.2 Sampling Design

The summer survey covers divisions 4V, 4W and 4X of the Northwest Atlantic Fisheries Organization (NAFO), which includes the Scotian Shelf and the Bay of Fundy. The eastern limit of the survey is the Laurentian Channel and the western limit is the Fundian Channel (Figure 1).

The survey follows a stratified random design (Doubleday and Rivard 1981; Lohr 1999) (Figure 3). The number of tows conducted in each stratum is approximately proportional to the surface area of the stratum. The targeted area covered by the survey has remained constant since its inception, with the exception of 1) additional deeper strata that were sampled a few times since 2000 and 2) some opportunistic coverage of the eastern portion of Georges Bank since 2011. Because the sampling of both the deeper strata and the eastern portion of Georges Bank is opportunistic and irregular, the analyses presented herein only include strata 440 to 466, 470 to 478, 480 to 485, and 490 to 495, which cover NAFO Divisions 4V, 4W and 4X (Figure 3 and Table 2). Strata 443, 444, 445 cover an area with mixed depths and are represented as a single polygon in Figure 3.

The basic sampling unit of the survey is a 30-minute fishing tow conducted at a speed of 3.5 knots. This yields a distance towed of 1.75 nautical miles.

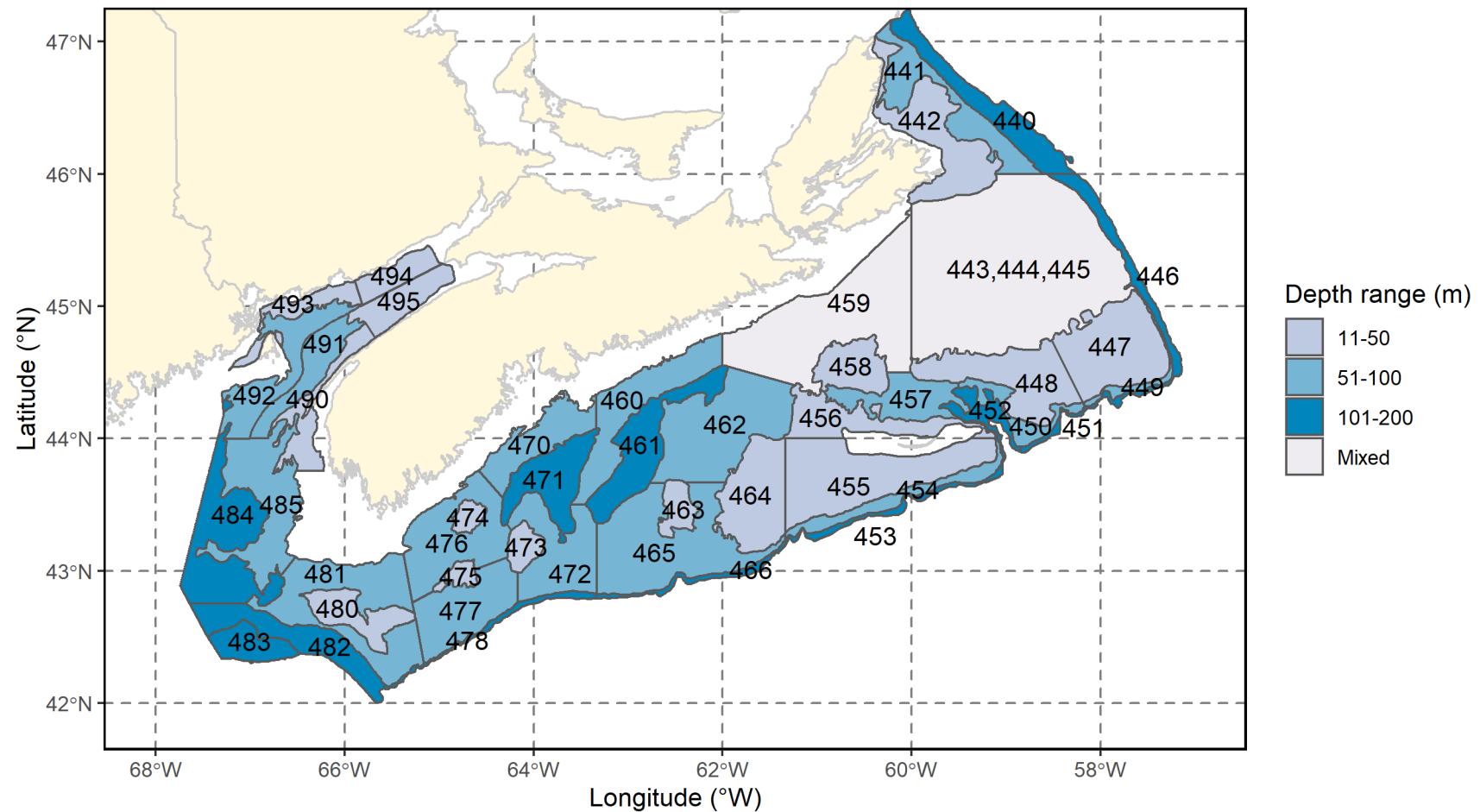


Figure 3. Map of the DFO Maritimes summer survey strata 440 to 495.

Table 2. Summer survey strata details. The strata used in the analyses are presented separately for NAFO Divisions 4Vn, 4VsW and 4X. For each stratum, the depth range is reported in fathoms and in meters, and the surface area is reported in square nautical miles and in square kilometers.

NAFO Div.	Stratum	Depth range (fathom)	Depth range (meter)	Area (nm ²)	Area (km ²)
4Vn	440	101-200	185-366	924	3,169
	441	51-100	93-183	1,000	3,430
	442	11-50	20-91	1,437	4,929
4VsW	443	11-50	20-91	1,318	4,521
	444	51-100	93-183	3,925	13,462
	445	101-200	185-366	1,023	3,509
	446	101-200	185-366	491	1,684
	447	11-50	20-91	1,616	5,543
	448	11-50	20-91	1,449	4,970
	449	51-100	93-183	144	494
	450	51-100	93-183	383	1,314
	451	101-200	185-366	147	504
	452	101-200	185-366	345	1,183
	453	101-200	185-366	259	888
	454	51-100	93-183	499	1,712
	455	11-50	20-91	2,122	7,278
	456	11-50	20-91	955	3,276
	457	51-100	93-183	811	2,782
	458	11-50	20-91	658	2,257
	459	11-50	20-91	3,148	10,797
	460	51-100	93-183	1,344	4,610
	461	101-200	185-366	1,154	3,958
	462	51-100	93-183	2,116	7,258
	463	11-50	20-91	302	1,036
	464	11-50	20-91	1,297	4,449
	465	51-100	93-183	2,383	8,173
	466	101-200	185-366	226	775

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NAFO Div.	Stratum	Depth range (fathom)	Depth range (meter)	Area (nm ²)	Area (km ²)
4X	470	51-100	93-183	920	3,156
	471	101-200	185-366	1,004	3,444
	472	51-100	93-183	1,249	4,284
	473	11-50	20-91	265	909
	474	11-50	20-91	161	552
	475	11-50	20-91	156	535
	476	51-100	93-183	1,478	5,069
	477	51-100	93-183	1,232	4,226
	478	101-200	185-366	233	799
	480	11-50	20-91	655	2,247
	481	51-100	93-183	1,875	6,431
	482	101-200	185-366	1,042	3,574
	483	101-200	185-366	532	1,825
	484	101-200	185-366	2,264	7,765
	485	51-100	93-183	1,582	5,426
	490	11-50	20-91	601	2,061
	491	51-100	93-183	687	2,356
	492	51-100	93-183	1,086	3,725
	493	11-50	20-91	533	1,828
	494	11-50	20-91	417	1,430
	495	11-50	20-91	584	2,003
Total				50,032	171,606

After each tow the catch is sorted by species and weighed. Each fish caught is then measured, and further sampling of individual fish weight, maturity status and age are performed for different length classes. When catches exceed 300 individuals, a random sub-sample is used to obtain the length and weight measurements.

2.3 Taxonomic Levels

Fish species caught during the surveys are identified by trained scientific personnel and their scientific name is determined. An internal species code used in the relational database is reported for each species (Losier and Waite 1989). There are a few instances where a number of species are assigned to a single species code (e.g. *Sebastes* and *Myctophidae* species).

By its nature as a bottom trawl, the fishing gear used in the survey catches certain species better than others. To ensure that meaningful ecological information can be extracted from catch samples, we report the catch records for the subset of species that are caught reliably by the gear. To appear in this atlas, a species must have been observed a minimum of 10 times over

the duration of the survey activities. While both catch abundance and weight are recorded, the weight of species that appear at low abundances is often recorded as zero in the earlier parts of the survey when scales of appropriate precision were not available. Another important factor to consider when analyzing weights is the change from spring scales to electronic balances that occurred in the 1990s. This change will affect the error structure of weight observations but should not introduce a bias in the measurements.

We divided the species caught into six categories based on 1) their taxonomic classification, 2) the number of recorded observations (i.e. the number of sets were a species was recorded), and 3) their period of valid identification (Table 3). Category "LF", for "long frequent", was assigned to species that have been caught in more than 1,500 sets since 1970 and have been consistently identified since the onset of the survey. Category "LI", for "long intermediate", was assigned to species that were caught in 1,500 to 200 sets. Category "LIn", for "long intermediate, using catch numbers", was assigned to species that were caught in 200 to 1,500 sets but whose weights were not consistently recorded over the duration of the survey. Rare and elusive species (those caught in less than 200 sets over the duration of the survey) are also reported but to a lower level of analytical details (Category "LR", for "long rare"). Category "SF", for "short frequent", was assigned to invertebrate species that were consistently sampled only since 1999 (Tremblay et al. 2007). Finally, category "SR", for "short rare", for invertebrate species consistently sampled only since 1999 and caught in less than 200 sets. Note that a number of other species are episodically caught in the survey, but are omitted from this report because their low catchability by trawl gear makes them unsuitable for analyses. To ensure concordance with authoritative taxonomic information, the AphiaID from the World Register of Marine Species (Appeltans et al. 2012) is included for the different species presented in this document (Table 4).

Table 3. Taxonomic levels used to determine the analytical treatment for each species.

Category	Name	Description
L	long - consistently identified since the onset of the survey in 1970	
LF	long frequent	species that have more than 1,500 catch records
LI	long intermediate	species that had between 200 and 1,500 catch records
LIn	long intermediate, using catch numbers	species that had between 200 and 1,500 catch records, but whose catch weights were not consistently recorded
LR	long rare	species with less than 200 catch records
S	short - invertebrate species that were consistently sampled only since 1999	
SF	short frequent	species with more than 200 catch records
SR	short rare	species with less than 200 catch records

Table 4. List of the 103 species included in the Atlas. For each taxonomic order and class, each species is listed in the table, its taxonomic family and scientific name are provided, along with its French and English common names, the species code used in the survey database with a link to the associated section in the document, its AphiaID with a link to the World Register of Marine Species, its number of catch records in the survey database and its classification category as defined in section 2.3.

Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Class: Myxini							
Order: Myxiniformes Myxinidae	<i>Myxine glutinosa</i>	Atlantic hagfish	Myxine du nord	<u>241</u>	101170	804	LI
Class: Petromyzonti							
Order: Petromyzontiformes Petromyzontidae	<i>Petromyzon marinus</i>	Sea lamprey	Lamproie marine	<u>240</u>	101174	16	LR
Class: Actinopterygii							
Order: Anguilliformes Nemichthysidae	<i>Nemichthys scolopaceus</i>	Slender snipe eel	Avocette ruban	<u>604</u>	126306	28	LR
Order: Argentiniiformes Argentinidae	<i>Argentina silus</i>	Greater argentine	Grande argentine	<u>160</u>	126715	963	LI
Order: Aulopiformes Chlorophthalmidae	<i>Chlorophthalmus agassizi</i> <i>Parasudis truculenta</i>	Shortnose greeneye Longnose greeneye	Éperlan du large Oeil-vert à long nez	<u>156</u> <u>149</u>	126336 158868	78	LR
Paralepididae	<i>Arctozenus risso</i>	White barracudina	Lussion blanc	<u>712</u>	126352	196	LR
Order: Beloniformes Scomberesocidae	<i>Scomberesox saurus</i>	Atlantic saury	Balaou atlantique	<u>720</u>	126392	37	LR
Order: Clupeiformes Clupeidae	<i>Alosa pseudoharengus</i> <i>Alosa sapidissima</i> <i>Clupea harengus</i>	Alewife American shad Atlantic herring	Gaspareau Alose savoureuse Hareng de l'Atlantique	<u>62</u> <u>61</u> <u>60</u>	158669 158670 126417	977 468 3,487	LI LI LF
Order: Gadiformes							

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Gadidae	<i>Gadus morhua</i>	Atlantic cod	Morue franche	<u>10</u>	126436	5,451	LF
	<i>Melanogrammus aeglefinus</i>	Haddock	Aiglefin	<u>11</u>	126437	5,827	LF
	<i>Microgadus tomcod</i>	Atlantic tomcod	Poulamon atlantique	<u>17</u>	158928	44	LR
Lotidae	<i>Pollachius virens</i>	Pollock	Goberger	<u>16</u>	126441	2,787	LF
	<i>Brosme brosme</i>	Cusk	Brosme	<u>15</u>	126447	688	LI
	<i>Enchelyopus cimbricus</i>	Fourbeard rockling	Motelle à quatre barbillons	<u>114</u>	126450	693	LI
Macrouridae	<i>Coryphaenoides rupestris</i>	Roundnose grenadier	Grenadier de roche	<u>414</u>	158960	17	LR
	<i>Nezumia bairdii</i>	Marlin-spike grenadier	Grenadier du Grand Banc	<u>410</u>	183289	529	LI
	<i>Trachyrincus murrayi</i>	Roughnose grenadier	Grenadier-scie	<u>412</u>	126481	18	LR
Merlucciidae	<i>Merluccius albidus</i>	Offshore silver hake	Merlu argenté du large	<u>19</u>	158748	161	LR
	<i>Merluccius bilinearis</i>	Silver hake	Merlu argenté	<u>14</u>	158962	4,936	LF
	<i>Phycis chesteri</i>	Longfin hake	Merluche à longues nageoires	<u>112</u>	158988	784	LI
<i>Order: Lophiiformes</i>	<i>Urophycis chuss</i>	Red hake	Merluche écureuil	<u>13</u>	126503	2,195	LF
	<i>Urophycis tenuis</i>	White hake	Merluche blanche	<u>12</u>	126504	3,524	LF
	<i>Lophiidae</i>	Monkfish	Baudroie d'Amérique	<u>400</u>	159184	1,970	LF
Ogcocephalidae	<i>Dibranchus atlanticus</i>	Atlantic batfish	Malthe atlantique	<u>742</u>	126558	18	LR
<i>Order: Myctophiformes</i>							
Myctophidae	Myctophidae	Lanternfishes	Poissons-lanternes	<u>150</u>	125498	160	LR
<i>Order: Osmeriformes</i>							
Osmeridae	<i>Mallotus villosus</i>	Capelin	Capelan	<u>64</u>	126735	540	LIn
	<i>Osmerus mordax</i>	Rainbow smelt	Éperlan arc-en-ciel	<u>63</u>	126737	59	LR
<i>Order: Perciformes</i>							

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Ammodytidae	<i>Ammodytes dubius</i>	Sand lance	Lançon	<u>610</u>	151520	1,283	LIn
Anarhichadidae	<i>Anarhichas denticulatus</i>	Northern wolffish	Loup à tête large	<u>52</u>	126757	17	LR
	<i>Anarhichas lupus</i>	Atlantic wolffish	Loup atlantique	<u>50</u>	126758	1,572	LF
	<i>Anarhichas minor</i>	Spotted wolffish	Loup tacheté	<u>51</u>	126759	20	LR
Callionymidae	<i>Foetorepus agassizii</i>	Spotfin dragonet	Dragonnet tacheté	<u>637</u>	276339	20	LR
Cryptacanthodidae	<i>Cryptacanthodes maculatus</i>	Wrymouth	Terrassier tacheté	<u>630</u>	159675	120	LR
Labridae	<i>Tautogolabrus adspersus</i>	Cunner	Tanche-tautogue	<u>122</u>	159785	82	LR
Pholidae	<i>Pholis gunnellus</i>	Rock gunnel	Sigouine de roche	<u>621</u>	126996	21	LR
Scombridae	<i>Scomber scombrus</i>	Atlantic mackerel	Maquereau commun	<u>70</u>	127023	696	LIn
Stichaeidae	<i>Eumesogrammus praecisus</i>	Fourline snakeblenny	Quatre-lignes atlantique	<u>626</u>	159817	40	LR
	<i>Leptoclinus maculatus</i>	Daubed shanny	Lompénie tachetée	<u>623</u>	127072	443	LIn
	<i>Lumpenus lampretaeformis</i>	Snakeblenny	Lompénie-serpent	<u>622</u>	154675	423	LIn
	<i>Ulvaria subbifurcata</i>	Radiated shanny	Ulvaire deux-lignes	<u>625</u>	159821	145	LR
	<i>Peprilus triacanthus</i>	Atlantic butterfish	Stromaté fossette	<u>701</u>	159828	487	LIn
Zoarcidae	<i>Lycenchelys verrillii</i>	Wolf eelpout	Lycode à tête longue	<u>603</u>	159258	40	LR
	<i>Lycodes lavalaei</i>	Newfoundland eelpout	Lycode du Labrador	<u>620</u>	127107	72	LR
	<i>Lycodes reticulatus</i>	Arctic eelpout	Lycode arctique	<u>641</u>	127112	70	LR
	<i>Lycodes terraenovae</i>	Newfoundland eelpout	Lycode du Labrador	<u>619</u>	127117	64	LR
	<i>Lycodes vahlii</i>	Vahl's eelpout	Lycode à carreaux	<u>647</u>	127118	565	LI
	<i>Melanostigma atlanticum</i>	Atlantic soft pout	Molasse atlantique	<u>646</u>	127120	43	LR

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
	Zoarces americanus	Ocean pout	Loquette d'Amérique	640	159267	1,478	LF
<i>Order: Pleuronectiformes</i>							
Cynoglossidae	Syphurus diomedeanus	Spottedfin tonguefish	Langue fil noir	816	159358	24	LR
Paralichthyidae	Citharichthys arctifrons	Gulf Stream flounder	Plie du Gulf Stream	44	158791	382	LIn
	Hippoglossina oblonga	Fourspot flounder	Cardeau à quatre ocelles	142	158833	76	LR
Pleuronectidae	Glyptocephalus cynoglossus	Witch flounder	Plie grise	41	127136	4,301	LF
	Hippoglossoides platessoides	American plaice	Plie canadienne	40	127137	6,023	LF
	Hippoglossus hippoglossus	Atlantic halibut	Flétan de l'Atlantique	30	127138	1,634	LF
	Limanda ferruginea	Yellowtail flounder	Limande à queue jaune	42	158879	3,233	LF
	Pseudopleuronectes americanus	Winter flounder	Limande-plie rouge	43	158885	1,632	LF
	Reinhardtius hippoglossoides	Greenland halibut	Flétan du Groenland	31	127144	736	LIn
Scophthalmidae	Scophthalmus aquosus	Windowpane flounder	Turbot de sable	143	158907	115	LR
<i>Order: Scorpaeniformes</i>							
	Aspidophoroides monopterygius	Alligatorfish	Poisson-alligator atlantique	340	159459	1,029	LIn
	Leptagonus decagonus	Atlantic poacher	Agone atlantique	350	127191	266	LIn
	Ulcina olrikii	Arctic alligatorfish	Poisson-alligator arctique	341	274356	13	LR
Cottidae	Artediellus atlanticus	Atlantic hookear sculpin	Hameçon atlantique	880	127193	258	LIn
	Artediellus uncinatus	Arctic hookear sculpin	Hameçon neigeux	306	127195	306	LIn

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Cyclopteridae	<i>Icelus spatula</i>	Spatulate sculpin	Icèle spatulée	<u>314</u>	127200	40	LR
	<i>Myoxocephalus aenaeus</i>	Grubby	Chaboisseau bronzé	<u>303</u>	159519	40	LR
	<i>Myoxocephalus octodecemspinosus</i>	Longhorn sculpin	Chaboisseau à dix-huit épines	<u>300</u>	159520	3,292	LF
	<i>Myoxocephalus scorpius</i>	Shorthorn sculpin	Chaboisseau à épines courtes	<u>301</u>	127203	131	LR
	<i>Triglops murrayi</i>	Moustache sculpin	Faux-trigle armé	<u>304</u>	127205	1,182	LF
	<i>Cyclopterus lumpus</i>	Lumpfish	Lompe	<u>501</u>	127214	216	LI
	<i>Eumicrotremus spinosus</i>	Atlantic spiny lumpsucker	Petite poule de mer atlantique	<u>502</u>	127217	226	LIn
Hemitripteridae	<i>Hemitripterus americanus</i>	Sea raven	Hémithriptère atlantique	<u>320</u>	159518	2,126	LF
Liparidae	<i>Careproctus reinhardtii</i>	Sea tadpole	Petite limace de mer	<u>520</u>	127212	18	LR
	<i>Liparis atlanticus</i>	Atlantic seasnail	Limace atlantique	<u>503</u>	159524	34	LR
	<i>Liparis fabricii</i>	Gelatinous snailfish	Limace gélatineuse	<u>505</u>	127218	27	LR
	<i>Liparis gibbus</i>	Variegated snailfish	Limace marbée	<u>512</u>	159526	41	LR
Psychrolutidae	<i>Cottunculus microps</i>	Polar sculpin	Cotte polaire	<u>307</u>	127235	29	LR
Sebastidae	<i>Helicolenus dactylopterus</i>	Blackbelly rosefish	Sébaste chèvre	<u>123</u>	127251	610	LIn
	<i>Sebastes</i>	Atlantic redfishes	Sébastes de l'Atlantique	<u>23</u>	126175	4,152	LF
<i>Order: Stomiiformes</i>							
Sternopychidae	<i>Maurolicus muelleri</i>	Silvery lightfish	Brossé améthyste	<u>158</u>	127312	52	LR
	<i>Sternopychidae</i>	Hatchetfishes	Haches d'argent	<u>741</u>	125603	21	LR
Stomiidae	<i>Stomias boa</i>	Boa dragonfish	Dragon-boa	<u>159</u>	127374	20	LR
<i>Order: Zeiformes</i>							
Zeidae	<i>Zenopsis conchifer</i>	Silvery John dory	Saint Pierre argenté	<u>704</u>	127426	39	LR

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
Class: Elasmobranchii							
<i>Order: Rajiformes</i>							
Rajidae	<i>Amblyraja radiata</i> <i>Dipturus laevis</i> <i>Leucoraja erinacea</i> <i>Leucoraja ocellata</i> <i>Malacoraja senta</i>	Thorny skate Barndoor skate Little skate Winter skate Smooth skate	Raie épineuse Grande raie Raie hérisson Raie tachetée Raie lisse	201 200 203 204 202	105865 158548 158551 158553 158554	3,937 246 712 1,180 1,773	LF LI LI LF LF
<i>Order: Squaliformes</i>							
Etmopteridae	<i>Centroscyllium fabricii</i>	Black dogfish	Aiguillat noir	221	105906	31	LR
Squalidae	<i>Squalus acanthias</i>	Piked dogfish	Aiguillat commun	220	105923	1,985	LF
Class: Cephalopoda							
<i>Order: Myopsida</i>							
Loliginidae	<i>Doryteuthis pealeii</i>	Longfin inshore squid	Calmar totam	4512	574541	96	LR
<i>Order: Oegopsida</i>							
Ommastrephidae	<i>Illex illecebrosus</i>	Northern shortfin squid	Encornet rouge nordique	4511	153087	4,836	LF
Class: Malacostraca							
<i>Order: Decapoda</i>							
Cancridae	<i>Cancer borealis</i> <i>Cancer irroratus</i>	Jonah crab Atlantic rock crab	Crabe nordique Crabe commun	2511 2513	158056 158057	1,387 788	SF SF
Geryonidae	<i>Chaceon quinquedens</i>	Red deepsea crab	Crabe rouge	2532	158407	33	SR
Lithodidae	<i>Lithodes maja</i>	Atlantic king crab	Crabe épineux du nord	2523	107205	531	SF
Nephropidae	<i>Homarus americanus</i>	American lobster	Homard américain	2550	156134	1,623	SF
Oregoniidae	<i>Chionoecetes opilio</i> <i>Hyas araneus</i>	Queen crab Great spider crab	Crabe des neiges Crabe lyre araignée	2526 2527	107315 107322	1,546 625	SF SF

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Family	Scientific name	English name	French name	Species code	AphiaID	Num. records	Category
	Hyas coarctatus	Arctic lyre crab	Crabe Hyas coarctatus	2521	107323	711	SF
Pandalidae	Pandalus borealis	Northern prawn	Crevette nordique	2211	107649	718	SF

2.4 Analyses

The Oracle relational database where all survey data are stored and archived is accessible from the Bedford Institute of Oceanography in Dartmouth, Nova Scotia. Queries written in Structured Query Language (SQL) are used to extract the data from the production server and to create the data products used in all subsequent analyses. Catch records classified as "valid" (i.e. coming from a representative tow without damage to the net, and coded as "type=1" in the Oracle database) are used in the current analyses. To make the available samples comparable, catch weight for each species was standardized for the distance towed. The results of the different comparative fishing experiments (Koeller and Smith 1983; Fanning 1984; Fowler and Showell 2009) show the existence of differences in the fishing efficiency of fishing platforms for some species. However, correction factors were only computed for six species by Fanning (1984), and the correction factors derived from other comparative fishing experiments, and for other species, were never unequivocally agreed upon in peer-review meetings (Don S. Clark, pers. comm.). To provide a synoptic overview for all the species considered in this report, no further correction factors are used in the present analyses.

All data processing and analyses were conducted using the R software (R Core Team 2021) using packages gstat (Pebesma 2004), PBSmapping (Schnute et al. 2019), RODBC (Ripley and Lapsley 2019), spatstat (Baddeley 2015), maptools (Bivand and Lewin-Koh 2020), rgeos (Bivand and Rundel 2020), classInt (Bivand 2020), RColorBrewer (Neuwirth 2014), MASS (Ripley et al. 2020), worms (Holstein 2018), and tidyverse (Wickham 2019). The present document is rendered as a Technical Report using the csasdown R package (Anderson et al. 2021).

2.4.1 Geographic distribution of catches

Spatial interpolation of catch (biomass/tow or abundance/tow) was done using a weighting inversely proportional to the distance (inverse-distance weighted, IDW), using function "idw" of the spatstat R package (Baddeley 2015). To achieve a visually appropriate rendition of the available catch data, the IDW method uses a power parameter value of 10. The IDW predictions are over a fixed grid with a resolution of 200 by 200 on the bounding box of the georeferenced survey data.

2.4.2 Abundance and biomass indices

For each species, stratified random estimates of catch biomass or abundance (Smith 1996) were computed for each year. Yearly estimates of the standard error were also computed. It must be noted that these are likely to be overestimates of the true stratified variance (Smith (1997)) and may lead to negative values for the lower confidence limits. In years where some strata were not sampled, the stratified estimate is calculated ignoring the missed strata. This implicitly assumes that the captures in the missed strata were the same as the overall mean. If a species does not follow this assumption in the missed strata the estimate will be biased. As such, the values presented herein should be treated with further analytical detail to ascertain that the estimate is unbiased.

2.4.3 Distribution indices

For each Category L and S species, the minimum area required to account for 75% and 95% of the total biomass were computed (D75% and D95%). For each category LIn species, the minimum area required to account for 75% and 95% of the total abundance were computed (D75% and D95%). These measures of distributions were computed for each year by using the Lorenz curve of mean stratum-level catch estimates and the area of occupied strata (Swain and Sinclair 1994; Swain and Morin 1996).

2.4.4 Length frequencies

The length frequency distribution of catch (the stratified numbers-at-length) is tabulated for each seven-year period (1970-2009), and last ten-year period (2010-2020). The stratified numbers-at-length is similar to the stratified random estimates of abundance (Smith 1996), but is calculated yearly for each length interval.

2.4.5 Length-weight relationship and condition factor

For Category LF species, individual records of fish length and weight are used to estimate the overall length-weight relationship of each species. The following non-linear allometric relationship is fitted to observations for each species:

$$W = \alpha L^\beta$$

where W is the observed weight (g), L is the length (cm), and, α and β are estimated parameters. The estimated parameters are used to compute a predicted weight based on an individual's length. The predicted weight and the observed weight are used to calculate each individual's relative fish condition (C) (as per Le Cren 1951):

$$C = \frac{W}{\alpha L^\beta}$$

Note that the fish condition for Atlantic herring (species code 60) is only calculated until 2015 since the survey protocol changed from fork length measurements in centimeters to total length measurements in millimeters in 2016 (Don S. Clark, pers. comm.).

2.4.6 Depth, temperature and salinity distribution of catches

For each category L species, we followed the methods developed by (Perry and Smith 1994) and generated cumulative frequency distributions of depth, temperature and salinity of survey catches. These cumulative frequency distributions can be compared to those obtained when using all survey sets in order to identify depth, temperature and salinity associations for the different species captured in the survey.

2.4.7 Density-dependent habitat selection

We followed the methods of (Myers and Stokes 1989) to evaluate how fish abundance in each stratum varied with overall temporal fluctuations of population abundance.

For each category L species, we fitted a model of the relationship between stratum-level density and overall abundance (the yearly stratified random estimate of abundance, defined above). To properly use the observations of zero catch while accounting for the logarithmic distribution of catch abundance, we implemented a generalized linear model using a log link and a Poisson error distribution:

$$Y_{h,i} = \alpha_h Y_i^{\beta_h}$$

where, $Y_{s,h,i}$ is the abundance in set s of stratum h in year i , and α_h and β_h are the fitted parameters. The estimated parameter β_h is referred to as the “slope parameter” and indicates whether stratum-level density is positively ($\beta_h <= 0$), negatively ($\beta_h >= 0$) or negligibly ($\beta_h \approx 0$) related to population abundance.

To estimate the suitability of each stratum, the median abundance observed during the years that are in the top 25% of yearly estimates is used. We combine the slope parameter estimates from the above model with the median abundance to identify strata that have consistently high abundance and whose local density is weakly related to fluctuation in population abundance ($\beta_h \approx 0$). Preferred strata are identified for each category L species.

2.5 Description of Figures

The figures generated for each species are presented in the Appendix and consist of up to six figures (Figure types A to F) per species, depending on their taxonomic level classification (as described in Section 2.3 above). The figure types are used as a suffix in each figure number.

2.5.1 Type A

For Category L species:

Spatial distribution of catch-per unit of effort, (CPUE, in kilograms per tow for LF and LI species, or in abundance per tow for LIn species) in July-August for the Bay of Fundy and Scotian Shelf for different time periods. The top-left map shows the first 10 years of available data (1970-1979). The other maps use data for 5-year (1980-1984, 1985-1989, 1990-1994, 1995-1999, 2000-2004, 2005-2009, 2010-2014) or 6-year (2015-2020) periods. Spatial interpolation between tows was done using Inverse Distance Weight (IDW). The probability of occurrence ($P(occ)$), the proportion of tows with catch records for a given species) was also reported for each five-year period.

For Category S species:

Spatial distribution of catch-per unit of effort, (CPUE, in kilograms per tow) in July-August for the Bay of Fundy and Scotian Shelf for different time periods. The maps use data for 4-year (1999-2002, 2003-2006, 2007-2010, 2011-2014, 2015-2018) or 2-year (2019-2020) periods. Spatial interpolation between tows was done using Inverse Distance Weight (IDW). The probability of occurrence (P_{occ}), the proportion of tows with catch records for a given species) was also reported for each five-year period.

For Category LR and SR:

Location of tows with catch over the period 1970-2020 (Type LR) or the period 1999-2020 (Type SR).

2.5.2 Type B

For Category LF, LI and S species:

Stratified random estimate of CPUE (left panel), distribution indices (D75% and D95%, the minimum area containing 75% and 95% of biomass, middle panel), and distribution vs. weight per tow (right panel). The stratified random mean is plotted as a solid line with the 95% confidence region indicated by the solid grey line. The overall mean is plotted as a grey horizontal line and the overall mean plus or minus 50% of the standard deviation appear as horizontal dashed lines. Values of zero are used in cases where the lower limit is a negative value. In all three panels, the early years appear in blue and the last years appear in red. The predictions from a loess estimator are overlaid on the distribution indices (middle panel). The Pearson correlation coefficient between D75% and biomass, and its statistical significance, are also reported in the right panel.

For Category LIn species:

Stratified random estimate of CPUE (left panel), distribution indices (D75% and D95%, the minimum area containing 75% and 95% of abundance, middle panel), and distribution vs. abundance per tow (right panel). The stratified random mean is plotted as a solid line with the 95% confidence region indicated by the solid grey line. The overall mean is plotted as a grey horizontal line and the overall mean plus or minus 50% of the standard deviation appear as horizontal dashed lines. In all three panels, the early years appear in blue and the last years appear in red. The predictions from a loess estimator are overlaid on the distribution indices (middle panel). The Pearson correlation coefficient between D75% and biomass, and its statistical significance, are also reported in the right panel.

2.5.3 Type C.

For Category LF species:

Length frequency distribution for NAFO divisions 4X and 4VW. A smoothed length frequency distribution is shown for each 7-year periods for the period 1970 to 2009, and for the last last ten-year period (2010 to 2020).

2.5.4 Type D.

For Category LF species:

Yearly average fish condition for all fish lengths (black dots and black line), with the 25th and 75th percentiles appearing as gray polygons. Fish condition is presented separately for NAFO divisions 4VW (right panel) and 4X (left panel).

2.5.5 Type E.

For Category LF species:

Cumulative frequency distributions of depth, temperature and salinity at all sampled locations (thick solid line) and at fishing locations with catch records (thin dashed line). The depth, temperature and salinity associated with 5%, 25%, 50%, 75% and 95% of the cumulative catch is shown in tabular fashion on the bottom right panel.

2.5.6 Type F.

For Category LF species:

Slopes estimates from the density-dependent habitat selection model (y axis) plotted versus the median abundance during the top 25% of years. The red box and red labels indicate strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance. Each stratum is identified on the plot by the last two digits of its number.

3 Results

The figures generated for each species are presented in Section 6.

3.1 Summary of successful tows by year and stratum

A total of 9080 representative tows were conducted for the period spanning from 1970 to 2020 (Figure 4). Tables 5 to 10 present the number of tows conducted in each stratum and year.

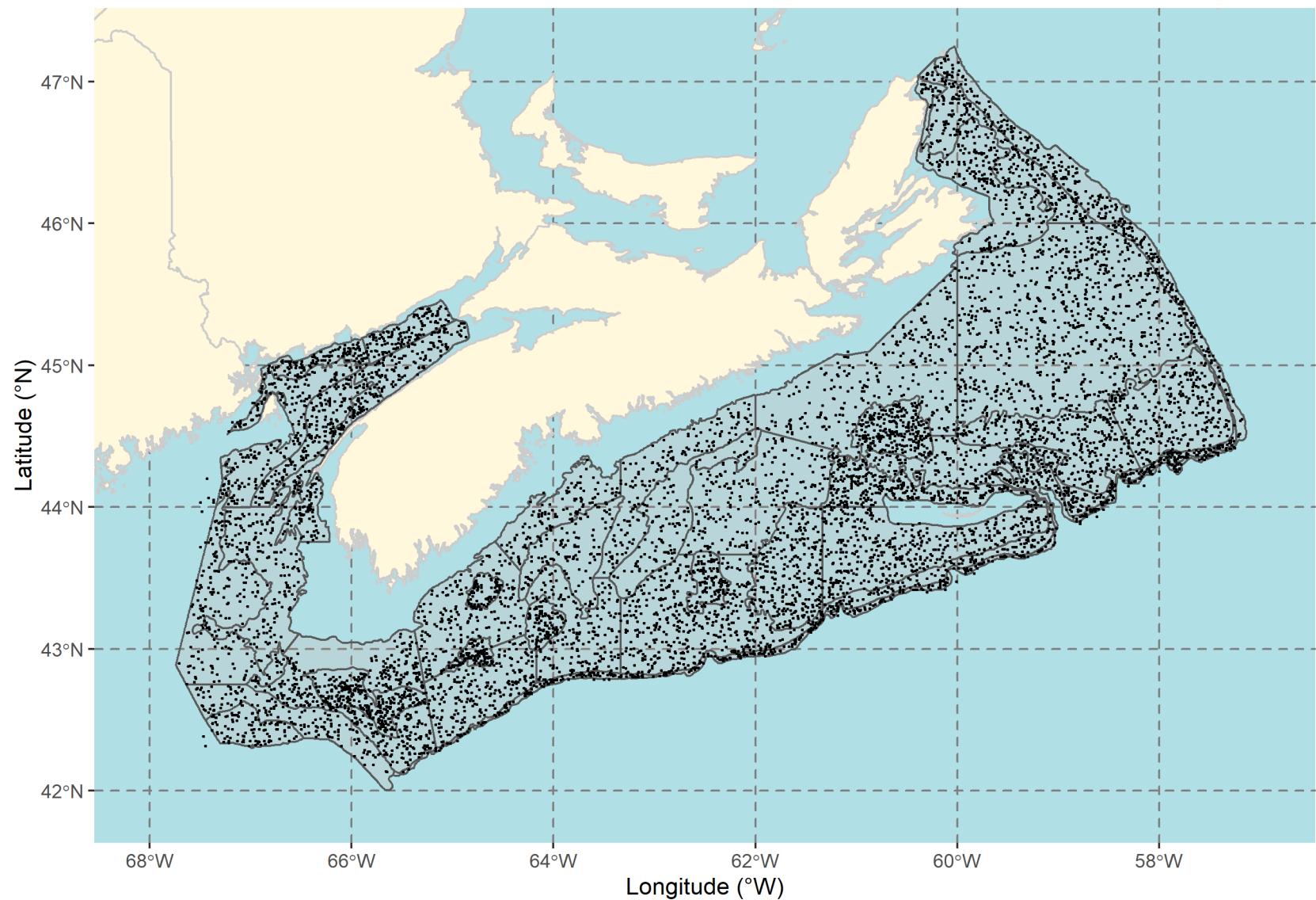


Figure 4. Map of the 9080 representative tows in the Summer survey from 1970 to 2020.

Table 5. Number of representative tows conducted in each stratum during the period 1970 to 1978.

Stratum	NAFO Div.	Area (km ²)	1970	1971	1972	1973	1974	1975	1976	1977	1978
440	4VN	3,173	4	2	2	3	3	3	3	3	3
441	4VN	3,434	4	2	2	3	3	3	1	3	3
442	4VN	4,935	3	2	2	2	3	3	2	3	3
443	4VSW	4,526	4	2	4	4	8	3	1	2	4
444	4VSW	13,478	3	2	5	4	6	4	6	7	4
445	4VSW	3,513	5	2	5	4	5	5	1	3	4
446	4VSW	1,686	2	2	3	3	3	3	3	3	3
447	4VSW	5,549	4	2	6	5	7	4	4	3	4
448	4VSW	4,976	5	2	5	4	5	4	4	4	4
449	4VSW	494	2	2	2	2	3	2	2	2	1
450	4VSW	1,315	2	2	3	2	3	3	3	3	3
451	4VSW	505	1	2	2	2	2	2	2	2	2
452	4VSW	1,185	2	2	2	2	2	2	2	2	2
453	4VSW	889	2	2	3	3	3	3	3	3	3
454	4VSW	1,714	3	2	3	3	3	3	3	3	3
455	4VSW	7,287	7	6	7	6	7	6	6	7	7
456	4VSW	3,279	5	4	6	5	5	6	4	6	6
457	4VSW	2,785	2	2	2	2	3	2	2	2	2
458	4VSW	2,260	3	3	3	3	3	3	3	3	3
459	4VSW	10,810	3	2	4	4	4	4	4	4	4
460	4VSW	4,615	2	2	2	2	1	2	2	2	2
461	4VSW	3,963	3	2	2	2	2	2	2	2	2
462	4VSW	7,266	3	3	4	3	4	4	4	4	4
463	4VSW	1,037	2	2	2	2	2	2	2	2	2
464	4VSW	4,454	4	3	5	3	3	6	5	5	5
465	4VSW	8,183	6	5	5	4	5	4	5	5	5
466	4VSW	776	2	2	3	2	3	3	3	3	3
470	4X	3,159	1	2	2	2	3	2	2	2	2
471	4X	3,448	2	2	2	2	2	2	2	2	2
472	4X	4,289	2	2	2	2	2	2	2	2	2
473	4X	910	2	2	2	2	2	2	2	2	2
474	4X	553	2	2	2	2	2	2	2	2	2
475	4X	536	2	2	2	2	2	2	2	2	2
476	4X	5,075	2	2	2	2	2	3	2	2	2
477	4X	4,231	2	2	2	2	2	2	2	2	2
478	4X	800	2	2	3	2	3	3	3	3	2
480	4X	2,249	4	4	4	3	3	3	4	4	3
481	4X	6,439	5	3	4	4	4	3	4	4	5
482	4X	3,578	2	1	2	2	2	2	3	2	2
483	4X	1,827	2	2	2	2	2	2	1	2	2
484	4X	7,775	2	2	3	3	3	3	3	3	2
485	4X	5,433	2	2	2	3	3	3	3	3	3
490	4X	2,064	2	2	2	2	2	3	3	3	3
491	4X	2,359	2	2	3	3	3	3	3	3	3
492	4X	3,729	3	2	4	3	3	3	3	3	3
493	4X	1,830	1	2	3	3	3	3	3	3	3
494	4X	1,432	2	2	2	2	2	2	2	2	2
495	4X	2,005	2	2	2	2	2	2	2	2	1
Total		171,810	134	110	146	134	153	143	135	144	141

Table 6. Number of representative tows conducted in each stratum during the period 1979 to 1987.

Stratum	NAFO Div.	Area (km ²)	1979	1980	1981	1982	1983	1984	1985	1986	1987
440	4VN	3,173	3	3	3	3	3	3	4	5	5
441	4VN	3,434	3	3	3	3	3	3	5	5	4
442	4VN	4,935	3	3	3	3	3	3	3	5	6
443	4VSW	4,526	4	4	3	5	4	4	4	6	6
444	4VSW	13,478	4	4	5	5	6	4	4	6	6
445	4VSW	3,513	4	4	5	5	3	4	5	6	4
446	4VSW	1,686	3	3	3	3	3	3	4	3	3
447	4VSW	5,549	4	5	4	4	4	4	4	5	7
448	4VSW	4,976	4	4	6	4	4	4	4	5	5
449	4VSW	494	2	2	2	1	2	2	2	2	2
450	4VSW	1,315	3	3	3	3	3	3	3	3	3
451	4VSW	505	3	2	2	3	2	2	2	2	2
452	4VSW	1,185	2	2	4	2	2	2	2	2	3
453	4VSW	889	3	3	3	3	3	3	3	3	2
454	4VSW	1,714	3	3	2	3	3	3	3	3	2
455	4VSW	7,287	7	7	7	7	7	7	7	8	8
456	4VSW	3,279	6	6	7	6	6	6	6	6	7
457	4VSW	2,785	2	2	3	2	2	2	2	2	4
458	4VSW	2,260	3	3	3	3	3	3	3	5	5
459	4VSW	10,810	4	4	4	3	4	4	6	6	5
460	4VSW	4,615	2	2	2	2	2	2	2	4	3
461	4VSW	3,963	2	2	2	2	2	2	2	3	3
462	4VSW	7,266	4	6	4	4	4	4	4	6	5
463	4VSW	1,037	2	2	2	3	2	2	2	2	2
464	4VSW	4,454	5	5	5	4	5	5	5	7	6
465	4VSW	8,183	5	5	7	6	5	5	5	5	8
466	4VSW	776	3	3	2	3	3	3	3	3	2
470	4X	3,159	2	2	2	2	2	2	2	2	3
471	4X	3,448	2	2	2	2	2	2	2	2	2
472	4X	4,289	3	2	2	2	2	2	2	2	4
473	4X	910	2	2	2	2	2	2	2	2	2
474	4X	553	2	2	2	2	2	0	2	2	2
475	4X	536	2	2	2	2	2	2	2	2	2
476	4X	5,075	1	2	2	2	2	2	2	2	4
477	4X	4,231	3	2	2	2	2	2	2	2	5
478	4X	800	3	3	3	3	3	3	3	3	2
480	4X	2,249	4	3	3	4	4	4	4	4	4
481	4X	6,439	4	3	4	4	4	4	4	4	6
482	4X	3,578	3	2	2	2	2	2	2	2	3
483	4X	1,827	2	2	2	2	2	2	2	2	2
484	4X	7,775	3	3	3	4	3	3	3	3	4
485	4X	5,433	3	2	3	4	3	3	3	3	6
490	4X	2,064	2	3	3	3	3	3	3	3	4
491	4X	2,359	3	3	3	3	3	3	3	3	4
492	4X	3,729	3	3	3	3	3	3	3	3	4
493	4X	1,830	3	3	2	3	3	3	3	3	3
494	4X	1,432	2	2	2	2	2	2	2	2	2
495	4X	2,005	2	2	2	2	2	2	2	2	2
Total		171,810	147	145	150	150	146	143	152	171	188

Table 7. Number of representative tows conducted in each stratum during the period 1988 to 1996.

Stratum	NAFO Div.	Area (km ²)	1988	1989	1990	1991	1992	1993	1994	1995	1996
440	4VN	3,173	6	4	4	4	4	3	4	4	4
441	4VN	3,434	4	4	6	5	5	5	5	5	5
442	4VN	4,935	7	5	5	5	6	5	6	6	6
443	4VSW	4,526	5	2	4	2	4	3	3	4	4
444	4VSW	13,478	3	6	7	8	8	9	6	8	8
445	4VSW	3,513	4	4	4	4	4	5	7	4	4
446	4VSW	1,686	3	3	3	3	3	2	3	3	3
447	4VSW	5,549	6	6	8	7	7	7	7	7	6
448	4VSW	4,976	5	5	9	6	6	7	7	7	6
449	4VSW	494	2	2	2	2	2	2	2	2	2
450	4VSW	1,315	3	3	3	3	3	3	3	3	3
451	4VSW	505	2	2	2	2	2	2	2	2	4
452	4VSW	1,185	2	2	3	2	2	2	2	2	2
453	4VSW	889	2	2	3	2	2	2	2	2	2
454	4VSW	1,714	2	2	3	2	2	2	2	2	3
455	4VSW	7,287	7	7	12	10	10	9	10	10	10
456	4VSW	3,279	6	6	10	7	7	8	8	8	8
457	4VSW	2,785	2	2	4	2	2	2	2	2	2
458	4VSW	2,260	3	3	9	8	8	8	8	8	7
459	4VSW	10,810	6	5	5	5	6	4	6	6	4
460	4VSW	4,615	3	3	3	3	3	3	3	3	3
461	4VSW	3,963	2	2	1	2	2	2	2	2	2
462	4VSW	7,266	4	4	5	5	4	4	4	4	4
463	4VSW	1,037	2	2	3	2	2	2	2	2	2
464	4VSW	4,454	5	5	9	7	7	7	7	7	7
465	4VSW	8,183	8	8	12	9	10	10	10	10	10
466	4VSW	776	2	2	3	2	2	2	2	3	2
470	4X	3,159	3	3	2	2	2	2	2	2	2
471	4X	3,448	2	2	2	2	2	2	2	2	1
472	4X	4,289	4	4	6	4	4	4	4	4	3
473	4X	910	2	2	3	2	2	2	2	2	2
474	4X	553	2	2	2	2	2	2	2	2	2
475	4X	536	2	2	2	2	2	2	2	2	2
476	4X	5,075	4	4	4	4	4	4	4	4	4
477	4X	4,231	4	4	5	5	5	5	5	5	5
478	4X	800	2	2	2	2	2	2	2	3	3
480	4X	2,249	4	4	8	8	8	8	8	8	8
481	4X	6,439	7	6	8	9	9	9	9	7	9
482	4X	3,578	3	3	3	3	3	3	3	3	3
483	4X	1,827	2	2	2	2	2	2	2	2	2
484	4X	7,775	4	4	3	3	3	3	3	3	3
485	4X	5,433	7	6	2	3	3	3	3	3	3
490	4X	2,064	4	4	4	4	4	4	4	5	4
491	4X	2,359	4	4	3	3	3	3	3	3	3
492	4X	3,729	4	4	3	3	3	3	3	2	3
493	4X	1,830	3	3	3	3	3	3	3	3	2
494	4X	1,432	2	2	2	2	2	2	2	2	2
495	4X	2,005	2	2	2	2	2	2	2	2	2
Total		171,810	177	170	213	189	193	190	195	195	191

Table 8. Number of representative tows conducted in each stratum during the period 1997 to 2005.

Stratum	NAFO Div.	Area (km ²)	1997	1998	1999	2000	2001	2002	2003	2004	2005
440	4VN	3,173	4	4	4	6	4	4	4	4	4
441	4VN	3,434	5	5	6	7	6	6	7	6	7
442	4VN	4,935	6	6	7	6	6	5	6	6	7
443	4VSW	4,526	5	5	4	5	4	5	5	5	4
444	4VSW	13,478	7	8	8	9	10	9	9	9	8
445	4VSW	3,513	4	3	3	6	5	5	5	5	6
446	4VSW	1,686	3	3	3	3	3	3	3	3	3
447	4VSW	5,549	7	7	6	7	7	7	7	7	7
448	4VSW	4,976	7	6	7	8	8	8	8	7	8
449	4VSW	494	1	2	2	2	2	2	2	2	2
450	4VSW	1,315	3	2	3	3	3	3	3	3	3
451	4VSW	505	2	2	2	2	2	2	2	2	2
452	4VSW	1,185	2	2	2	3	2	2	2	2	2
453	4VSW	889	2	2	2	2	2	2	2	2	2
454	4VSW	1,714	2	2	2	2	2	2	2	2	3
455	4VSW	7,287	13	8	11	11	11	11	11	8	12
456	4VSW	3,279	8	6	8	10	8	8	8	8	8
457	4VSW	2,785	2	2	1	4	2	2	2	2	2
458	4VSW	2,260	8	5	6	10	8	7	8	8	10
459	4VSW	10,810	5	6	6	8	6	6	6	6	6
460	4VSW	4,615	3	3	3	3	3	4	3	3	4
461	4VSW	3,963	2	2	2	2	2	2	2	2	4
462	4VSW	7,266	4	4	4	4	4	4	4	4	5
463	4VSW	1,037	2	2	2	2	2	3	2	2	4
464	4VSW	4,454	4	7	7	7	7	7	7	5	8
465	4VSW	8,183	10	9	10	10	10	10	10	10	10
466	4VSW	776	2	3	2	2	2	2	2	2	2
470	4X	3,159	2	2	2	2	2	2	2	2	2
471	4X	3,448	2	2	2	2	2	2	2	2	2
472	4X	4,289	4	4	4	4	4	4	4	4	4
473	4X	910	2	2	2	2	2	3	2	2	2
474	4X	553	2	2	2	2	2	2	2	2	2
475	4X	536	2	2	2	2	2	3	2	2	2
476	4X	5,075	4	4	4	4	4	5	4	4	4
477	4X	4,231	5	5	5	5	5	5	5	5	8
478	4X	800	2	2	2	2	2	2	2	2	3
480	4X	2,249	8	8	8	7	8	8	8	7	9
481	4X	6,439	9	9	9	8	9	8	9	6	12
482	4X	3,578	3	3	3	3	3	3	3	2	4
483	4X	1,827	2	2	2	2	2	2	2	2	2
484	4X	7,775	3	3	3	3	3	4	3	3	4
485	4X	5,433	3	3	3	4	3	5	5	3	2
490	4X	2,064	4	4	3	4	4	4	6	4	3
491	4X	2,359	3	3	3	3	3	3	5	3	3
492	4X	3,729	3	3	3	3	3	3	5	2	3
493	4X	1,830	3	3	2	3	3	4	5	2	4
494	4X	1,432	2	2	2	2	2	3	4	2	2
495	4X	2,005	2	2	2	2	2	2	4	2	2
Total		171,810	193	186	191	213	201	208	216	188	222

Table 9. Number of representative tows conducted in each stratum during the period 2006 to 2014.

Stratum	NAFO Div.	Area (km ²)	2006	2007	2008	2009	2010	2011	2012	2013	2014
440	4VN	3,173	4	4	3	4	4	5	4	4	4
441	4VN	3,434	6	6	5	6	6	7	6	6	6
442	4VN	4,935	5	5	5	6	5	6	6	6	6
443	4VSW	4,526	4	4	5	4	4	6	5	5	3
444	4VSW	13,478	10	8	6	9	11	13	9	8	9
445	4VSW	3,513	5	4	3	6	4	7	2	4	3
446	4VSW	1,686	3	3	2	3	3	4	3	3	3
447	4VSW	5,549	6	6	4	6	6	8	6	7	7
448	4VSW	4,976	8	6	5	7	7	10	8	8	8
449	4VSW	494	2	2	2	2	2	4	2	2	2
450	4VSW	1,315	3	3	3	3	3	3	3	3	3
451	4VSW	505	2	3	2	2	2	2	2	2	2
452	4VSW	1,185	2	2	2	2	2	2	2	2	1
453	4VSW	889	2	3	1	2	2	1	3	2	3
454	4VSW	1,714	2	2	2	2	2	4	2	2	2
455	4VSW	7,287	11	7	5	8	10	10	10	11	11
456	4VSW	3,279	8	6	2	7	7	9	8	8	6
457	4VSW	2,785	2	2	2	2	2	4	2	2	2
458	4VSW	2,260	8	5	2	7	6	9	8	6	4
459	4VSW	10,810	6	5	3	6	6	7	6	6	6
460	4VSW	4,615	3	2	3	3	3	4	4	3	3
461	4VSW	3,963	2	2	2	2	2	3	3	2	2
462	4VSW	7,266	4	3	4	4	4	6	4	4	5
463	4VSW	1,037	2	2	2	2	2	3	2	2	2
464	4VSW	4,454	7	6	4	5	6	7	7	7	7
465	4VSW	8,183	10	7	8	7	8	10	10	10	10
466	4VSW	776	2	1	3	2	2	2	2	2	2
470	4X	3,159	2	2	2	2	2	2	3	2	2
471	4X	3,448	2	2	2	2	2	2	3	2	2
472	4X	4,289	4	3	4	3	4	6	4	4	4
473	4X	910	2	2	2	2	2	2	2	2	2
474	4X	553	2	2	2	2	2	2	2	2	2
475	4X	536	2	2	2	2	2	2	2	2	2
476	4X	5,075	4	4	4	4	4	4	4	4	4
477	4X	4,231	5	5	5	5	5	4	5	5	6
478	4X	800	2	2	2	2	2	2	2	2	2
480	4X	2,249	8	6	8	8	8	7	8	8	6
481	4X	6,439	9	7	8	8	8	10	9	9	9
482	4X	3,578	3	3	3	3	3	4	3	3	3
483	4X	1,827	2	2	2	2	2	3	2	2	2
484	4X	7,775	4	3	3	4	3	5	5	5	4
485	4X	5,433	5	4	5	5	5	6	5	5	5
490	4X	2,064	3	3	4	3	3	4	2	4	3
491	4X	2,359	4	3	4	4	4	4	4	4	4
492	4X	3,729	4	4	4	4	4	6	4	4	4
493	4X	1,830	4	3	3	4	3	4	4	4	3
494	4X	1,432	4	3	3	4	4	4	4	4	3
495	4X	2,005	5	3	3	4	3	4	4	4	2
Total		171,810	209	177	165	196	196	243	210	208	196

Table 10. Number of representative tows conducted in each stratum during the period 2015 to 2020 and for the whole 1970 to 2020 period.

Stratum	NAFO Div.	Area (km2)	2015	2016	2017	2018	2019	2020	Total
440	4VN	3,173	4	4	4	0	5	4	190
441	4VN	3,434	6	6	6	0	7	4	238
442	4VN	4,935	6	6	6	0	6	5	240
443	4VSW	4,526	7	4	5	0	9	4	214
444	4VSW	13,478	9	11	10	0	6	8	352
445	4VSW	3,513	4	4	4	0	6	3	215
446	4VSW	1,686	2	3	2	0	3	2	145
447	4VSW	5,549	7	7	7	0	6	5	291
448	4VSW	4,976	7	6	6	0	7	4	299
449	4VSW	494	2	2	2	0	2	2	100
450	4VSW	1,315	3	3	2	0	3	2	144
451	4VSW	505	2	2	2	0	2	2	104
452	4VSW	1,185	4	3	3	0	3	3	110
453	4VSW	889	2	2	1	0	2	2	116
454	4VSW	1,714	2	2	2	0	3	2	121
455	4VSW	7,287	9	9	8	0	9	6	429
456	4VSW	3,279	5	6	6	0	6	4	331
457	4VSW	2,785	3	3	3	0	3	2	113
458	4VSW	2,260	5	5	5	0	6	3	269
459	4VSW	10,810	7	7	6	0	9	7	262
460	4VSW	4,615	5	5	5	3	6	5	151
461	4VSW	3,963	3	3	3	2	3	3	113
462	4VSW	7,266	5	5	5	0	5	5	212
463	4VSW	1,037	3	2	2	0	2	2	107
464	4VSW	4,454	6	6	4	0	6	4	288
465	4VSW	8,183	10	9	7	3	10	7	397
466	4VSW	776	2	2	3	0	3	2	118
470	4X	3,159	3	3	3	4	3	2	112
471	4X	3,448	3	3	3	4	4	3	110
472	4X	4,289	4	4	4	4	4	4	172
473	4X	910	2	2	2	2	2	2	104
474	4X	553	2	2	2	2	2	2	100
475	4X	536	2	2	2	2	2	2	103
476	4X	5,075	5	5	5	5	5	5	177
477	4X	4,231	5	5	4	4	6	4	204
478	4X	800	2	2	3	2	2	2	119
480	4X	2,249	7	7	7	5	7	5	306
481	4X	6,439	8	10	9	6	9	6	350
482	4X	3,578	3	4	4	3	4	3	141
483	4X	1,827	2	3	3	2	3	2	105
484	4X	7,775	6	5	7	7	7	7	186
485	4X	5,433	6	6	6	4	6	5	196
490	4X	2,064	4	4	4	3	4	3	173
491	4X	2,359	4	4	4	3	4	3	168
492	4X	3,729	3	4	4	3	4	4	171
493	4X	1,830	3	4	6	3	3	3	159
494	4X	1,432	4	4	3	2	4	3	128
495	4X	2,005	4	4	4	3	4	3	127
Total		171,810	212	214	208	81	227	175	9,080

3.2 Distribution of depth, bottom temperature and bottom salinity from survey tows

The depth, bottom temperature, and bottom salinity cumulative frequency distribution for the survey are presented in Figure 5.

3.2.1 Decadal distribution of surface and bottom temperatures

The decadal cumulative frequency distribution of surface and bottom temperatures of representative sets from the DFO Maritimes summer survey showcase warmer values of both surface and bottom temperature in the last decade (Figure 6).

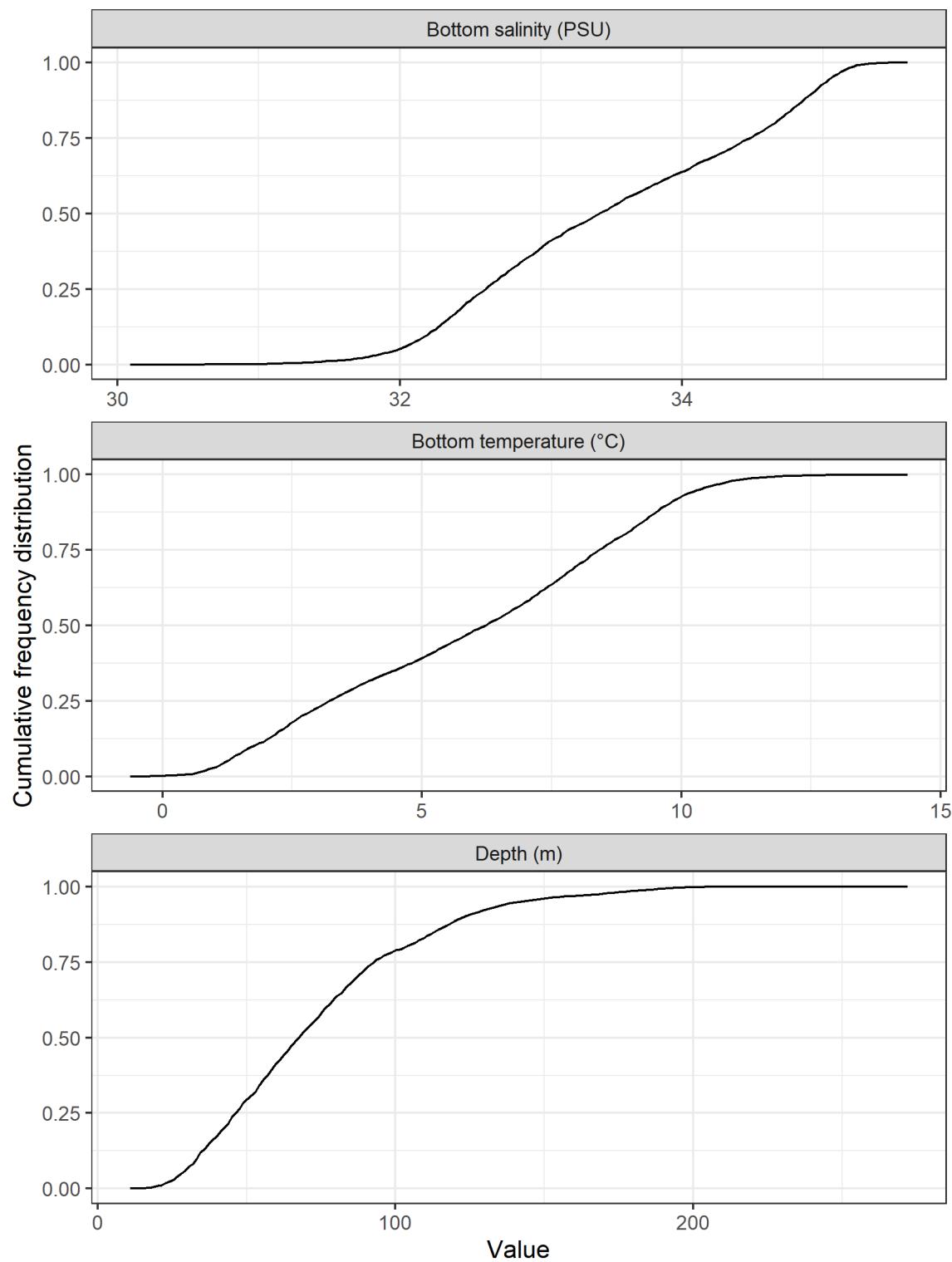


Figure 5. Cumulative frequency distribution of bottom salinity (top panel), bottom temperature (middle panel) and depth (bottom panel) of representative sets from the DFO Maritimes summer survey.

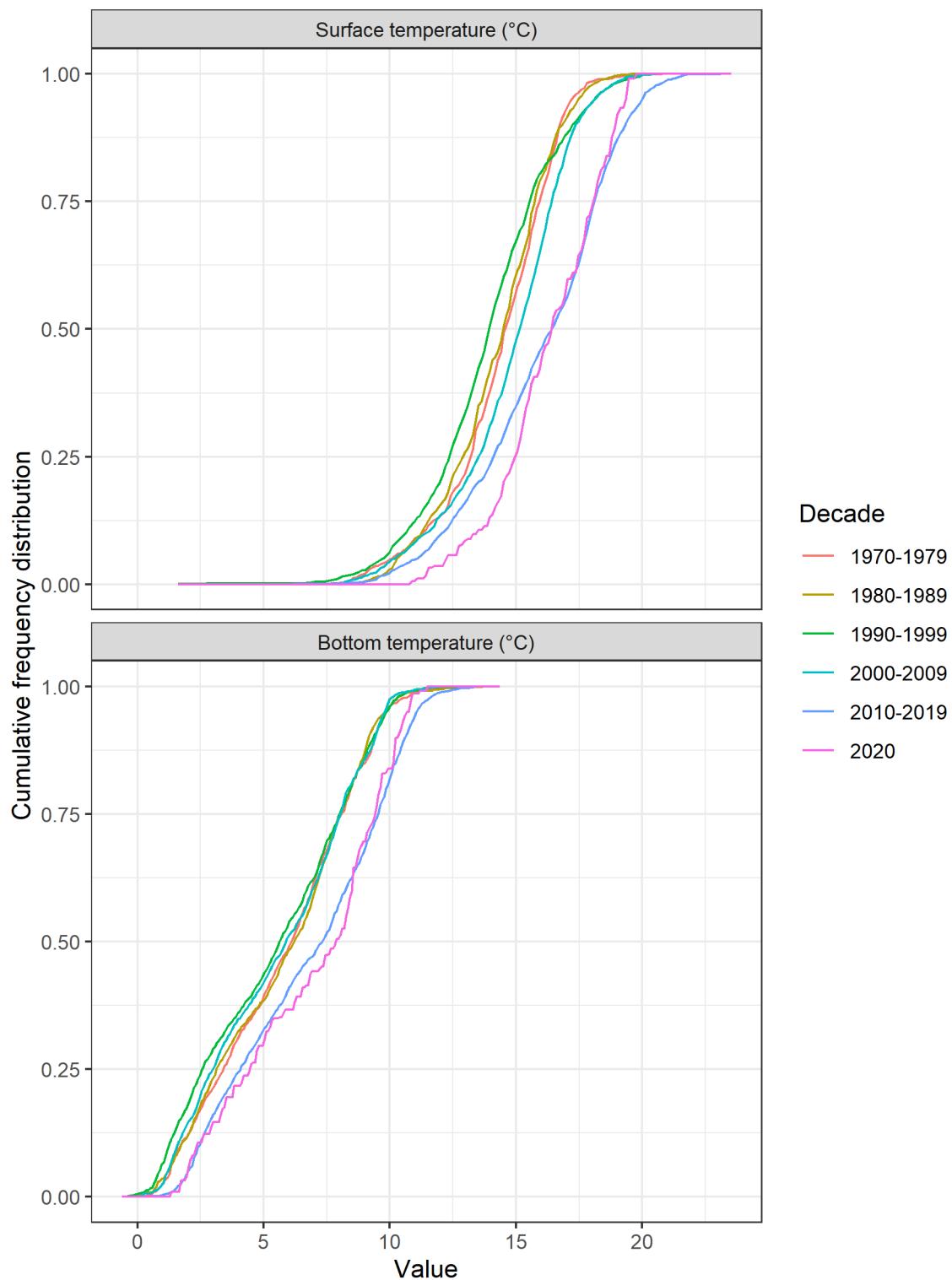


Figure 6. Decadal cumulative frequency distribution of surface temperature (top panel) and bottom temperature (bottom panel) of representative sets from the DFO Maritimes summer survey. Note warmer values of both surface and bottom temperature in the last decade.

4 Discussion

This report builds on previous work and former atlases by updating a comprehensive suite of indices to give a snapshot of population status and environmental associations of 103 fish and invertebrate species. The current document is not meant to replace stock assessments, species-specific analyses of abundance, biomass and distribution, or any targeted attempts to integrate information about species or group of species from the wide and disparate sources of data about marine organisms in the area covered by the DFO Maritimes summer trawl survey. It is rather meant to provide a reproducible set of tools to extract and visualize the information collected in the summer groundfish research vessel survey. It is hoped that this document can provide a stepping stone to conduct other ecological analyses using the trawl survey data and increase reproducibility and transparency of ecological information collected annually.

4.1 Diversity of approaches used for mapping fish and invertebrates in the Scotian Shelf bioregion

Different methods have been applied in the Northwest Atlantic, and specifically on the Scotian Shelf bioregion, to map fish and invertebrate species distribution. The present report, for example, builds upon the atlas of important habitat developed to map the persistence of relatively high biomass for key fish species using the summer groundfish research vessel survey (Horsman and Shackell 2009). Important habitat was obtained by interpolating observed weight by species using inverse-distance weighting (IDW), and calculating areas with relatively persistent high biomass for periods representing different fishery management eras. To complement information from this atlas, including additional representations of biomass and diversity, a similar IDW interpolation mapping procedure was followed by Smith et al. (2015), Ward-Paige and Bundy (2015), and Bundy et al. (2017). The summer groundfish research vessel survey is typically conducted during the month of July. However, from the fall of 1978 through to the spring of 1985, DFO also conducted spring and fall surveys using the same sampling design. This unique seasonal data was used to map the seasonal spatial distribution of key demersal and other fish species using IDW interpolation on the Scotian Shelf from the spring, summer and fall between 1978 and 1985 (Smith et al. 2015). Following recommendations provided by Kenchington and Kenchington (2017), the spatial distribution of three indicators of biodiversity for fish and invertebrates were mapped using IDW interpolation to identify areas with persistently high values across fishery management eras, and compared with areas of persistently high abundance for selected species (Ward-Paige and Bundy 2015). This analysis revealed a lack of consistent relationships between areas of persistent high diversity and persistent high biomass, suggesting that both can be used as independent and important spatial indicators of the system (Ward-Paige and Bundy 2015). Groupings of fishes and invertebrates based on size, habitat and feeding guild, were also mapped using IDW interpolations to identify hotspots of functional group diversity (Bundy et al. 2017). This analysis revealed a spatially and temporally variable distribution of functional diversity across the Scotian Shelf with notable areas of high and low diversity (Bundy et al. 2017). Top quintiles of each functional group using the IDW approach were used as representative layers for fish and invertebrates in the MPA Network design in the Scotian Shelf Bioregion (Serdynska et al. 2021). IDW interpolation methods have also been used to map the distribution of individual species such as sea cucumbers (*Cucumaria frondosa*)

in the Scotian Shelf bioregion (Shackell et al. 2013), and sea scallop (*Placopecten magellanicus*) in Georges and Browns Bank (Hubley et al. 2014).

Species Distribution Modelling (SDM), instead of IDW, can also be used to evaluate spatio-temporal dynamics by predicting and understanding past, present and future distribution of species using environmental predictors (Robinson et al. 2017). A variety of modelling approaches are being implemented in Maritimes Region to map and predict fish and invertebrate species distribution by incorporating environmental predictors to account for seasonal and temporal variability. For example, a stock assessment of snow crab (*Chionoecetes opilio*) on the Scotian Shelf used data from the snow crab survey from 2005 to 2018 to map spatial data products for this stock, including annual predicted interpolations of potential habitat using Generalized Additive Models (GAM) and several environmental covariates including depth, curvature, slope, species composition, and annual temperature (Zisserson et al. 2019). Sea scallop predicted habitat using Maximum Entropy (MaxEnt) models were computed for German Bank using data compiled via benthic habitat mapping and seafloor geotechnical surveys in 2006, 2009, and 2010 (Brown et al. 2012). Predictions in the Scotian Shelf bioregion and the Northeast United States using datasets from DFO and the National Oceanic and Atmospheric Administration from 1993 to 2012 also predicted sea scallop habitat at a wider scale based on three scenarios of seasonal temperature and salinity climatologies (NOAA) (Lowen et al. 2019). Offshore American lobster stock assessments (*Homarus americanus*) used data from the RV, DFO Georges Bank, and National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) bottom trawl surveys (1970 to 2015) to predict species distribution using boosted regression trees and several environmental predictors (bathymetry, slope, curvature, and annual temperature interpolations) (Cook et al. 2017). Information on the potential for recovery of cusk (*Brosme brosme*) used data from the bottom longline Halibut industry survey and Cusk absences in the Summer groundfish research vessel survey from 1998-2013 to predict suitable habitat using GAM, MaxEnt, and random forest models and several physical environmental variables (e.g. complexity, benthic current stress and complexity, temperature, salinity, primary production, chlorophyll, suspended matter) (Harris et al. 2018). Atlantic halibut (*Hippoglossus hippoglossus*) assessments using Summer groundfish research vessel survey and NOAA survey data from 2001 to 2013 predicted juvenile habitat using MaxEnt model and environmental predictors (bathymetry, slope, bottom temperature) (French et al. 2018). Persistent areas of high Atlantic halibut juvenile abundance were predicted using data from 27 bottom trawl surveys combined (NMFS and DFO) from 1978 to 2013 and applying Bayesian hierarchical spatiotemporal models with two environmental predictors (depth and temperature) (Boudreau et al. 2017).

These examples of mapping efforts in Maritimes Region showcase the diversity of approaches relevant to a variety of important research questions and management applications. Approaches, methods, datasets, and environmental predictors are selected based on individual project research questions, and considerations for each species, communities or stock. This allows research groups to maintain innovation and keep up with emerging methods and technologies to improve assessments, predictions, and ultimately, science advice. The diversity of approaches also leads to complexity when looking across studies as each data compilation and predictive method carries its own independent assumptions and can lead to different spatial outputs. This presents challenges for developing consistent spatial products for marine spatial planning.

4.2 Interpreting spatial results for marine spatial planning purposes

Fisheries and Oceans Canada is leading a marine spatial planning process that brings together relevant authorities and stakeholders to better coordinate how we use and manage marine spaces to achieve ecological, economic and social objectives. Operationalizing marine spatial planning includes a series of steps, including the process of analyzing existing conditions by collecting and mapping information about ecological, environmental and oceanographic conditions (Ehler and Douvere 2009; Agardy et al. 2011). Mapping the distribution of species is critical for the implementation of spatial management and as a first step in marine spatial planning processes. Species distribution have supported the identification of important sites for a given species or areas of high richness and diversity, which in turn can be used to inform siting decisions of new activities such as Marine Protected Areas (MPA), aquaculture sites or wind turbines. In the Scotian Shelf bioregion, mapping species distributions has been used to highlight areas of high biological diversity to support the identification of Ecologically or Biologically Significant Areas (Ricard and Shackell 2013; Ward-Paige and Bundy 2015), to distinguish important and persistent habitat of significant species and functional groups to support MPA and conservation planning (Horsman and Shackell 2009; Smith et al. 2015; Ward-Paige and Bundy 2015; Bundy et al. 2017), to identify important habitat for Species at Risk (Harris et al. 2018) and to highlight reserves for data-poor invertebrate fisheries (Shackell et al. 2013). Mapping species distribution has also been used to illustrate multi-decadal scale projections of changes in species distribution in the context of climate change and adaption (Stanley et al. 2018; Greenan et al. 2019).

In support of the marine spatial planning process, a public web-based atlas with relevant geospatial information is being developed to support decision-making. This Atlantic Canada-wide compilation of data and information will be a web-based, public platform with interactive maps of ocean ecosystems, human uses and management areas. The current document cannot present the full diversity of data and mapping products that can be produced for the Maritimes Region. Consequently, we recommend that the data and mapping products presented in this report not be used blindly for the planned atlas, until an evaluation of what spatial information is available and what was used in the past is conducted.

This diverse portfolio of approaches and applications is not unique to the Maritimes Region. A recent review of global distribution modelling efforts recommended the adoption of a consistent framework that integrates multi-model approaches and a clear expression of errors and uncertainties (Robinson et al. 2017). In this context, Pacific Region has developed two initiatives to enable consistency and frequent publication, reproducibility, and transparency. One initiative developed a reproducible report to give a synthesis of data availability, population trends, fishing trends, growth and maturity patterns for 113 groundfish species in British Columbia to support stock assessment (Anderson et al. 2019, 2020). The second initiative developed a SDM framework that was applied to twelve species on Canada's Pacific coast as part of the Regional Response Plan (Nephin et al. 2019). The Maritimes region, through this and past reports, are also using similar reproducible approaches to facilitate annual updates and transparency (Ricard and Shackell 2013).

Recognizing the diversity of approaches for mapping fish and invertebrates in the Scotian Shelf bioregion, we recommend the development of a regional community of practice to compare and evaluate approaches for mapping, interpolating and/or modelling fish and invertebrates

so future publications and advice related to spatial outputs can lead to more comparable work and consistent science advice to support processes such as marine spatial planning. At the international level, guidelines and standards related to appropriate variables and methods for mapping and modeling species and communities of deep-sea habitats were proposed to encourage the production of publications that will lead to more comparable work (Kenchington et al. 2019). Similar general guidance for how groups approach mapping activities would be a worthwhile product in the Maritimes Region. Until then, we propose the use of the Open Data record for the Maritimes RV surveys (DFO 2021) as a precursor to the public web-based marine spatial planning atlas.

5 Acknowledgements

We thank all the dedicated personnel involved in running trawl surveys in the Maritimes Region and the numerous colleagues in Maritimes Region that have shared information and advice in support of this report. The assistance of the Gulf Region secondary publications coordinator, Jeff Clements, in getting this report published is well appreciated. The document greatly benefited from the constructive comments of Adam Cook, Mariano Koen-Alonso and an anonymous reviewer.

6 Figures for all species analysed

The figures generated for each species are presented here and consist of up to six figures (Figure types A to F) per species, depending on their taxonomic level classification (as described in Section 2.3). The figure types are used as a suffix in each figure number.

To facilitate navigation, use the PDF navigation panel. Alternatively, Table 4 contains the list of all species presented and includes a hyperlink to the first page of figures for each species. Finally an Index is included at the end of the document, containing hyperlinks to each species based on its scientific name, English common name or French common name.

6.1 Atlantic cod (*Morue franche*) - species code 10 (category LF)

Scientific name: [Gadus morhua](#)

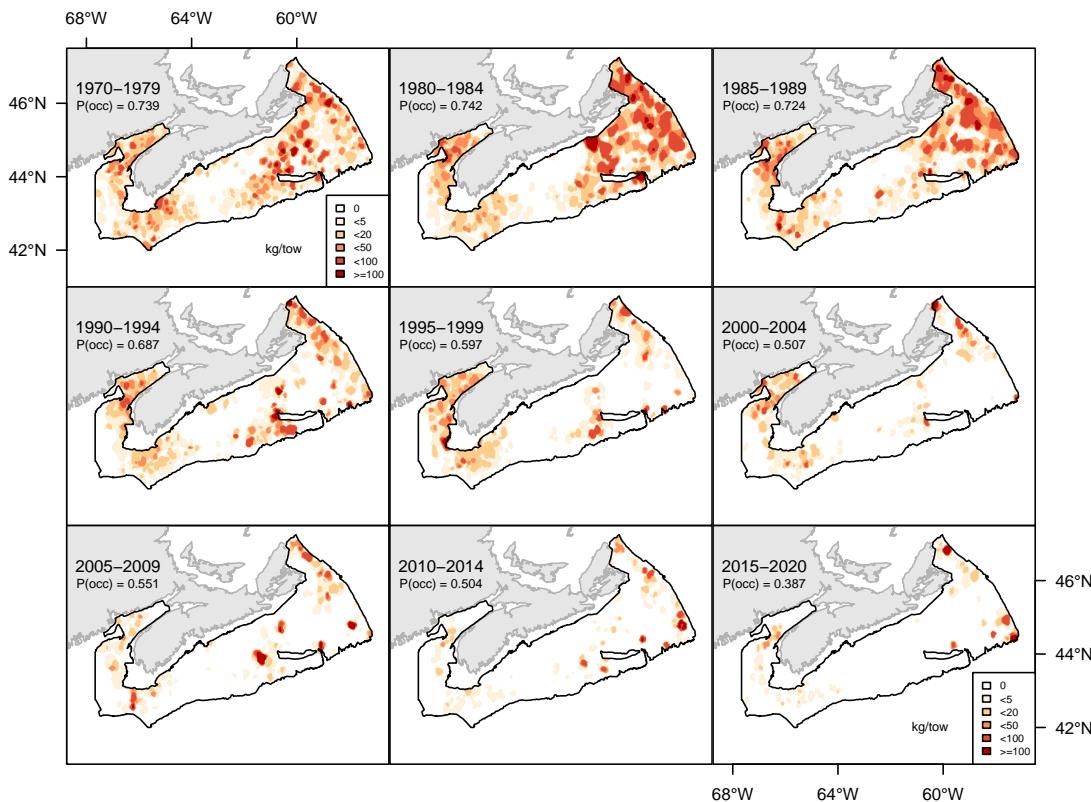


Figure 6.1A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic cod. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

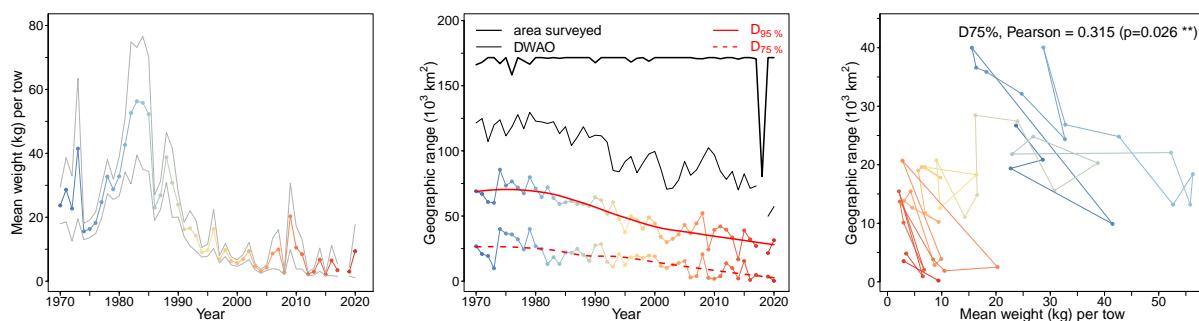


Figure 6.1B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic cod. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

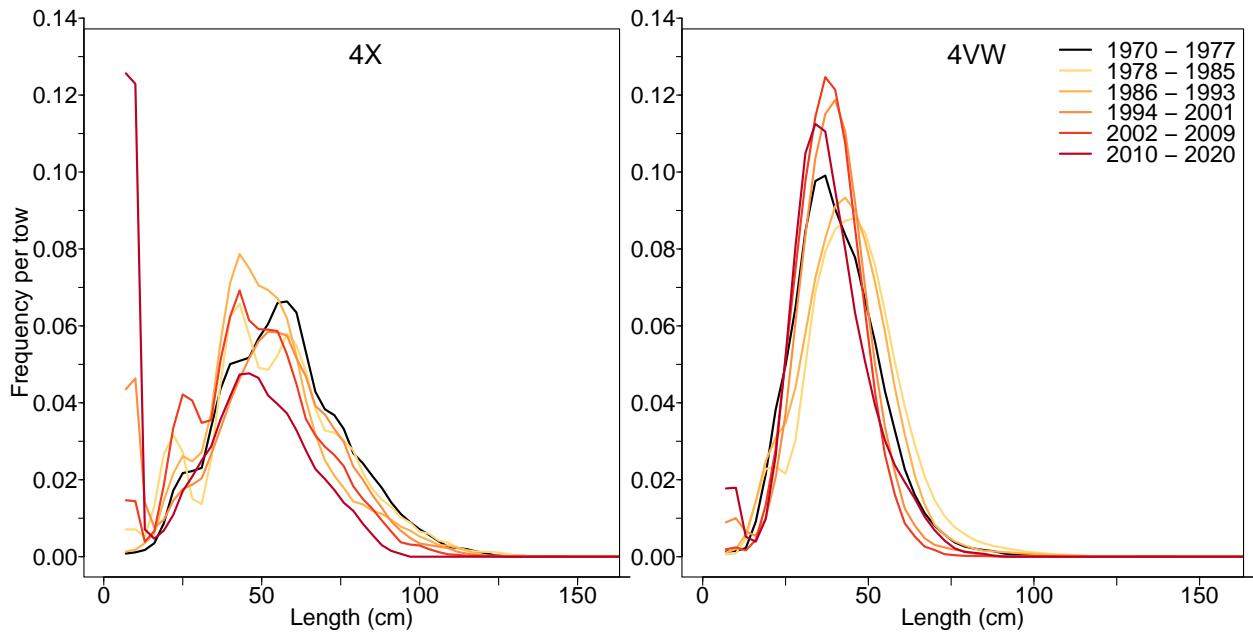


Figure 6.1C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic cod.

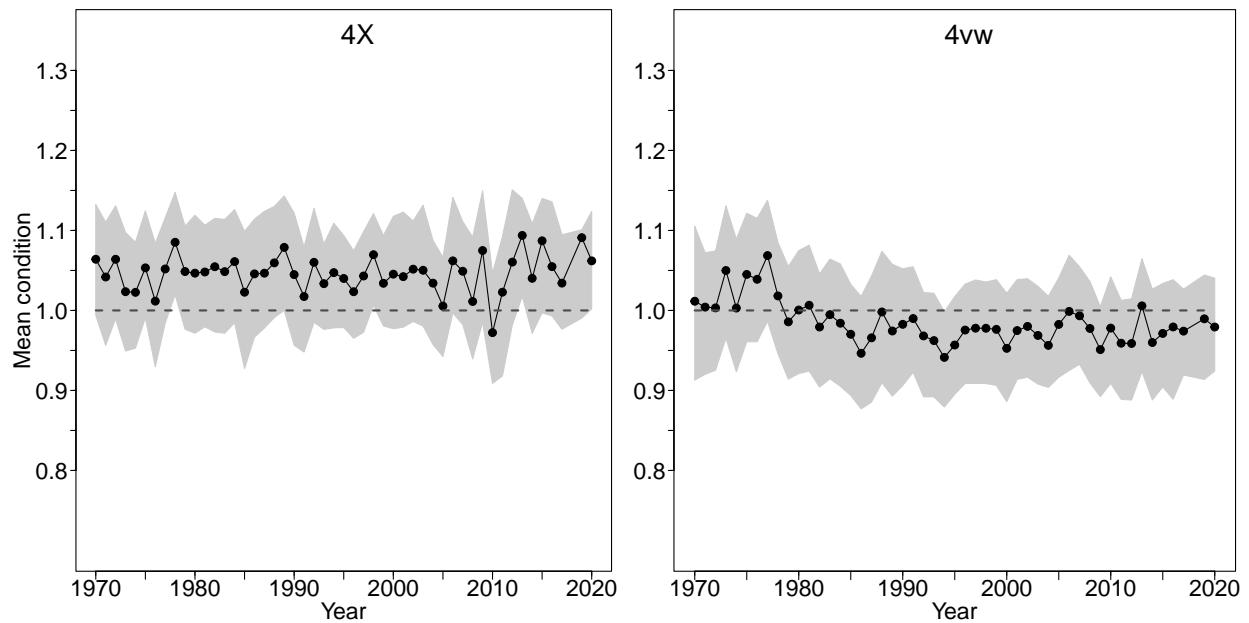


Figure 6.1D. Average fish condition in NAFO units 4X and 4VW for Atlantic cod.

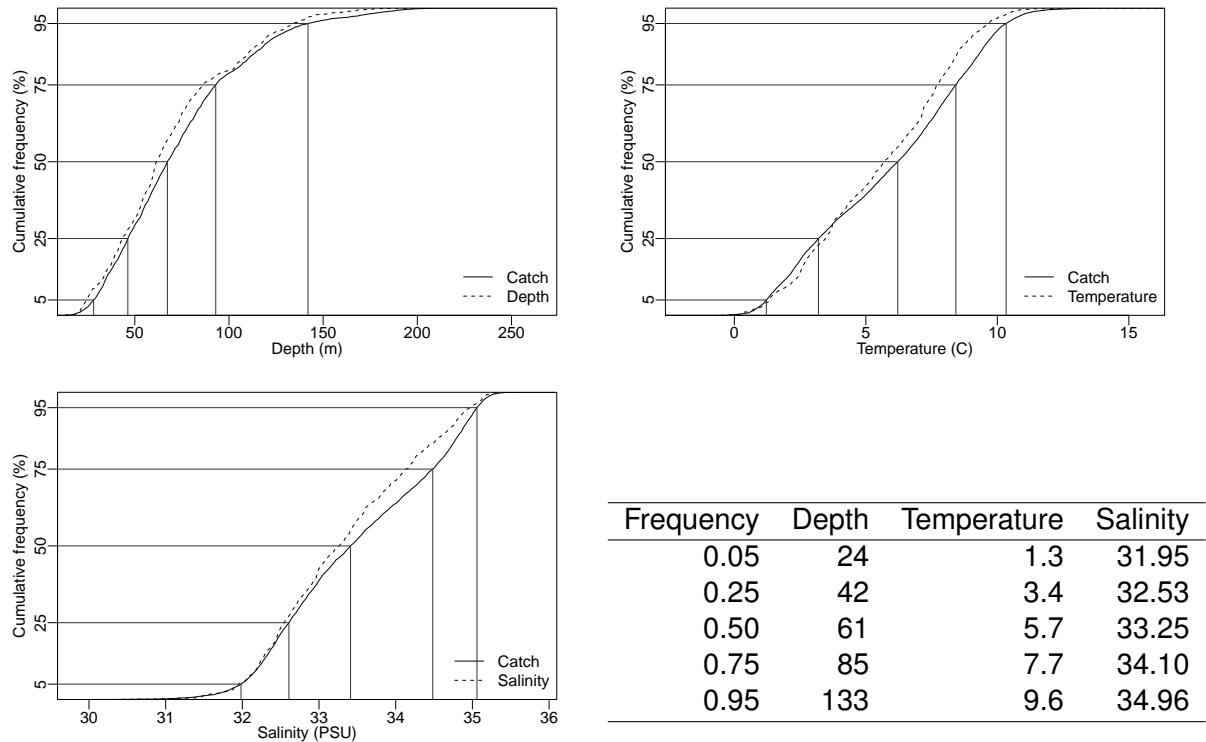


Figure 6.1E. Catch distribution by depth, temperature and salinity of Atlantic cod.

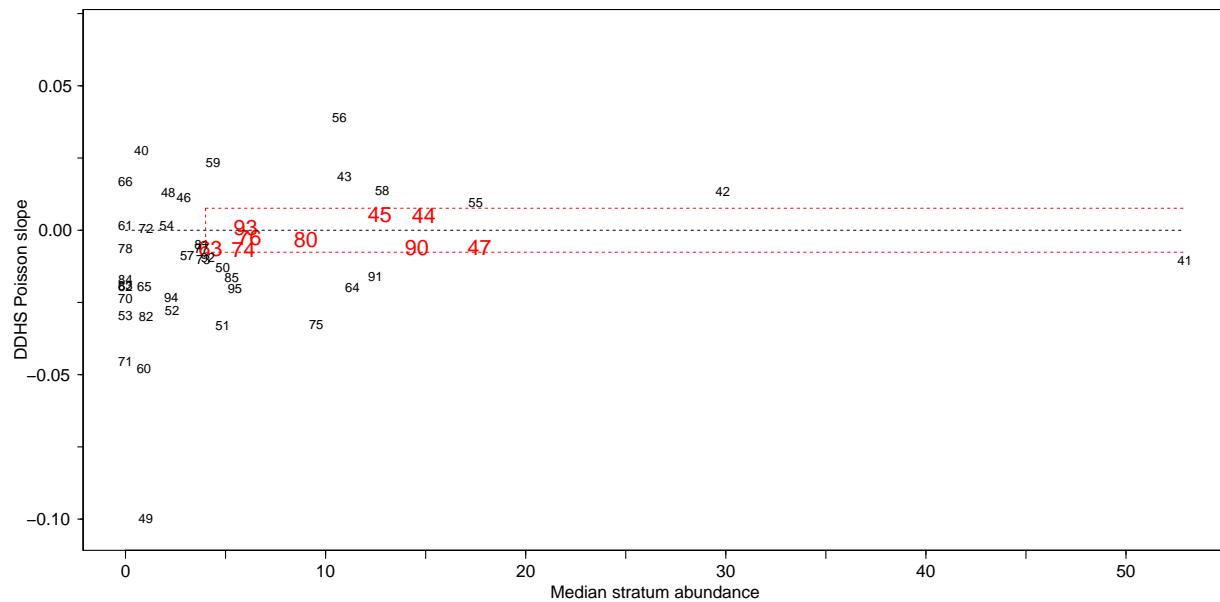


Figure 6.1F. DDHS slopes versus median stratum abundance for Atlantic cod. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.2 Haddock (Aiglefin) - species code 11 (category LF)

Scientific name: [Melanogrammus aeglefinus](#)

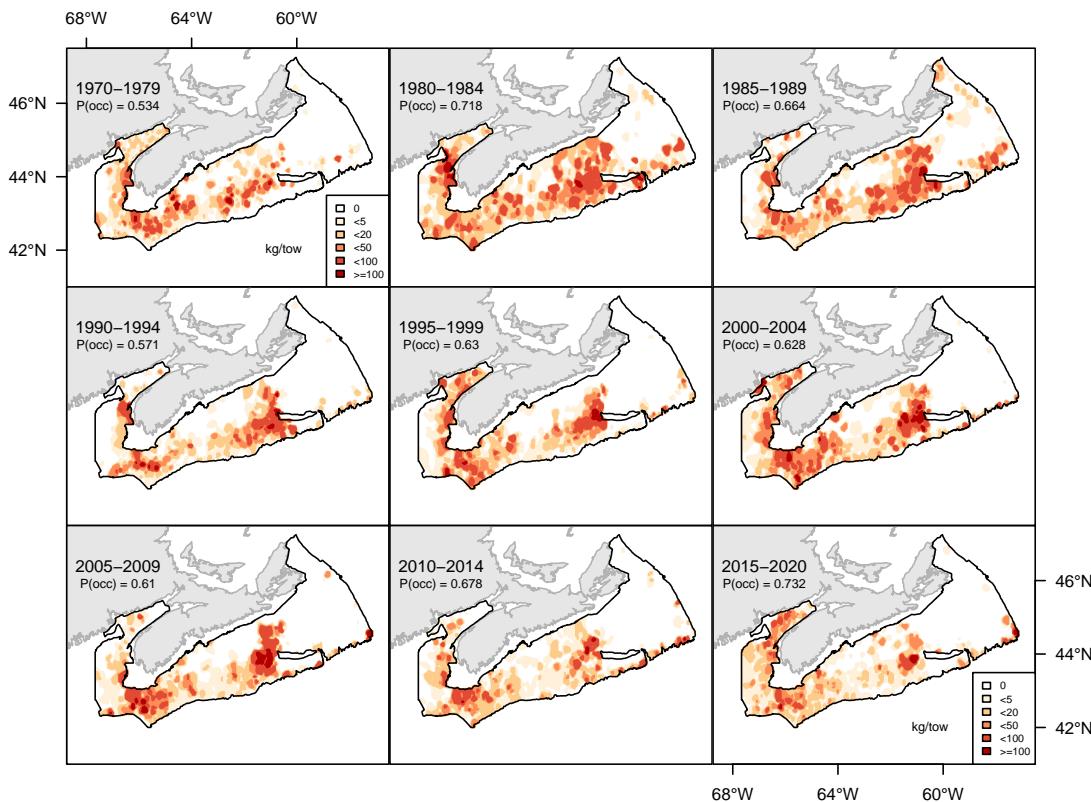


Figure 6.2A. Inverse distance weighted distribution of catch biomass (kg/tow) for Haddock. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

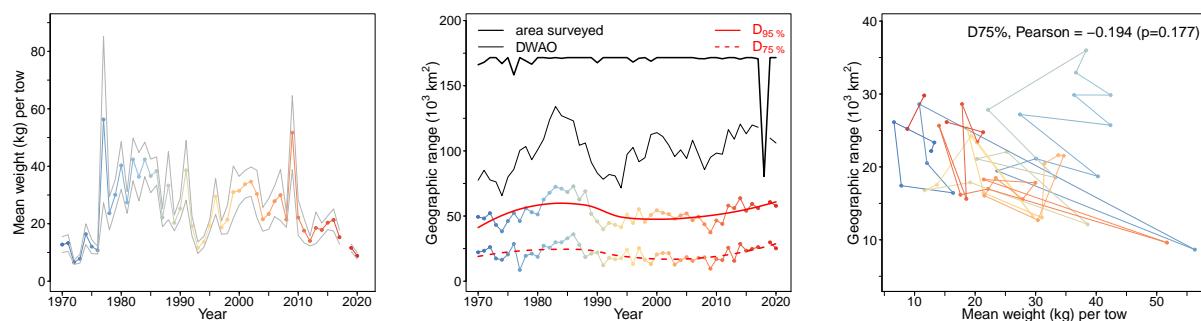


Figure 6.2B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Haddock. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

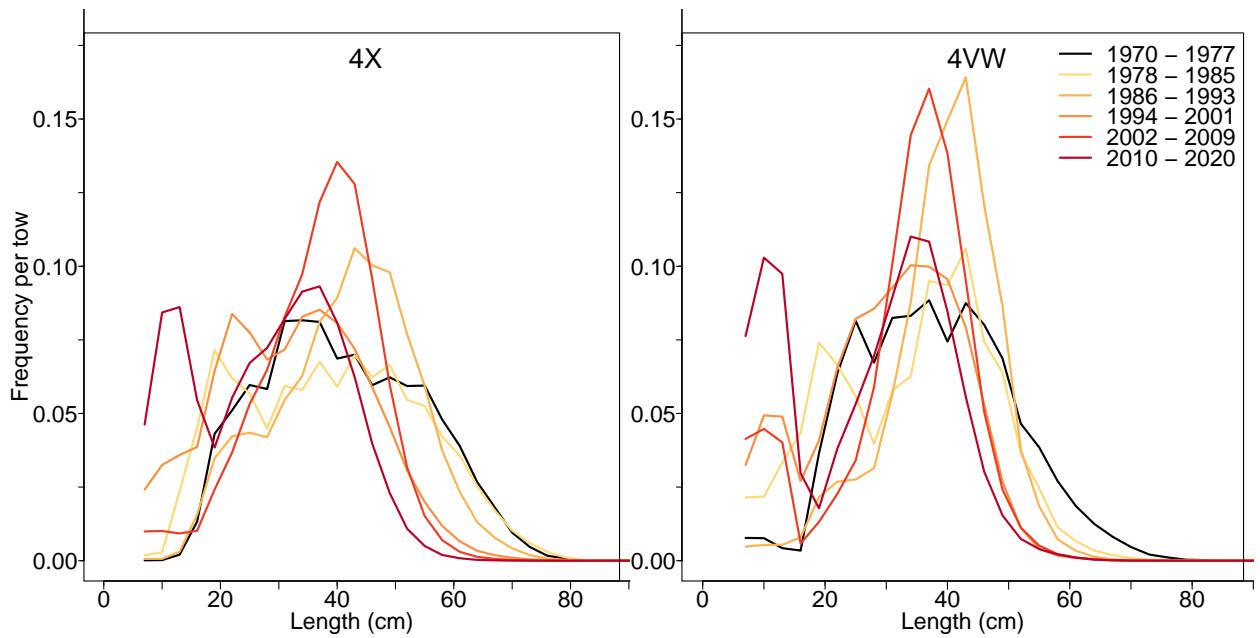


Figure 6.2C. Length frequency distribution in NAFO units 4X and 4VW for Haddock.

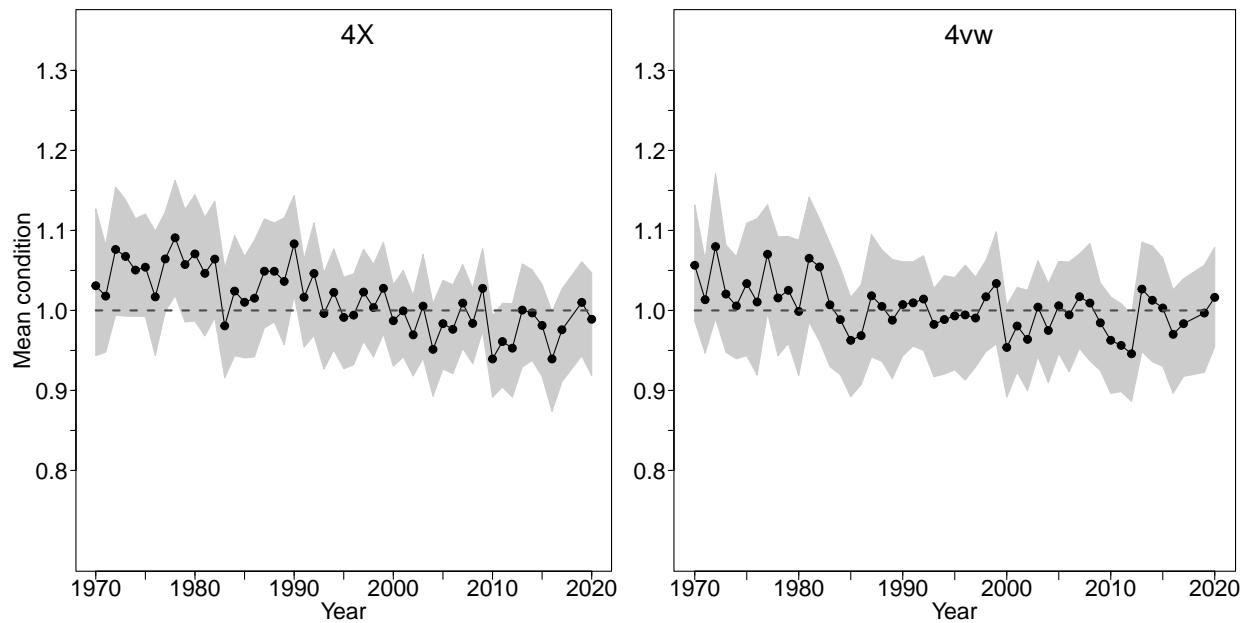


Figure 6.2D. Average fish condition in NAFO units 4X and 4VW for Haddock.

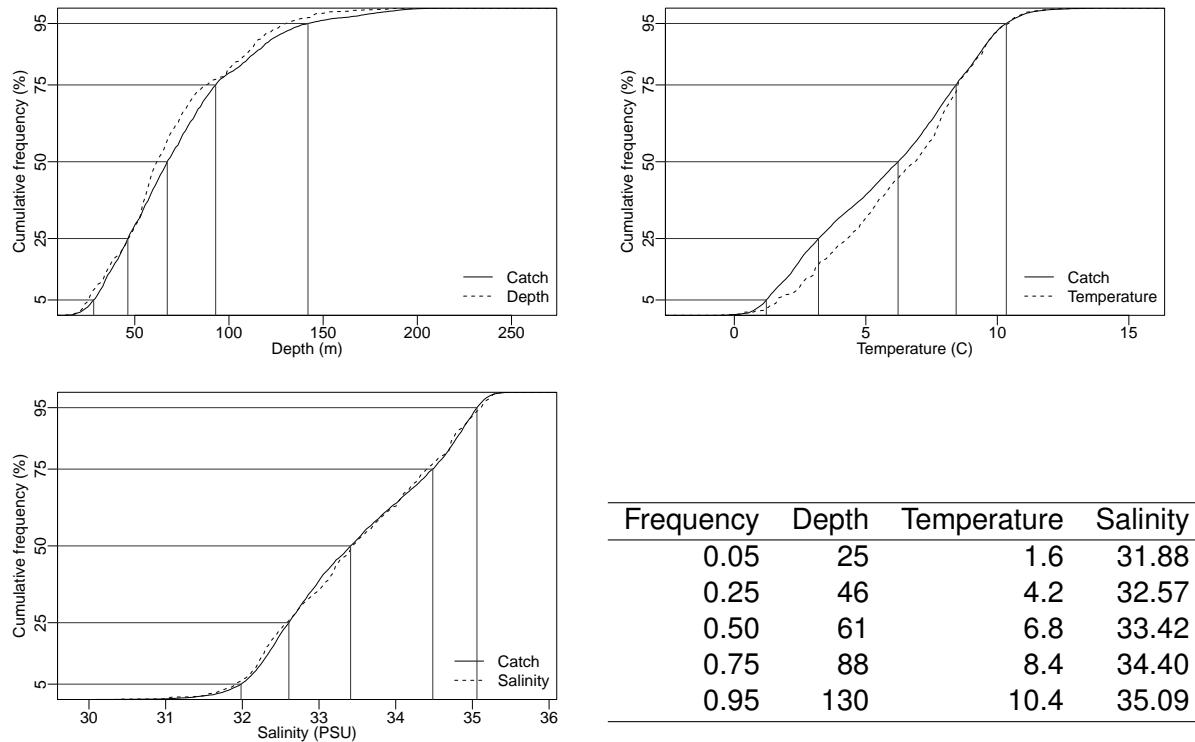


Figure 6.2E. Catch distribution by depth, temperature and salinity of Haddock.

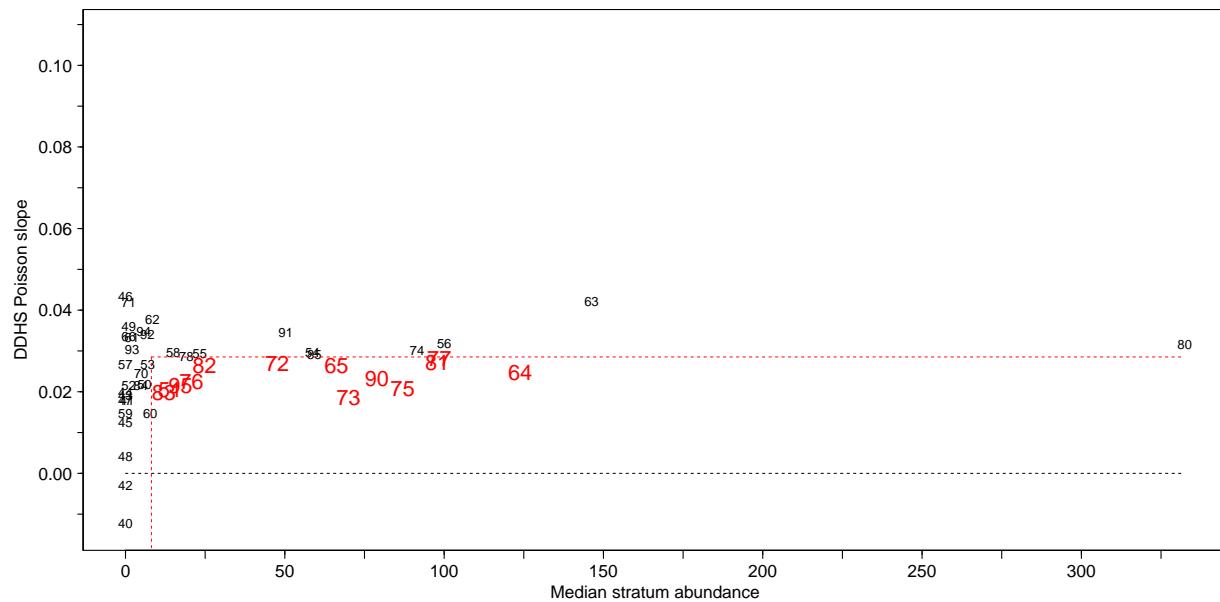


Figure 6.2F. DDHS slopes versus median stratum abundance for Haddock. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.3 White hake (Merluche blanche) - species code 12 (category LF)

Scientific name: [*Urophycis tenuis*](#)

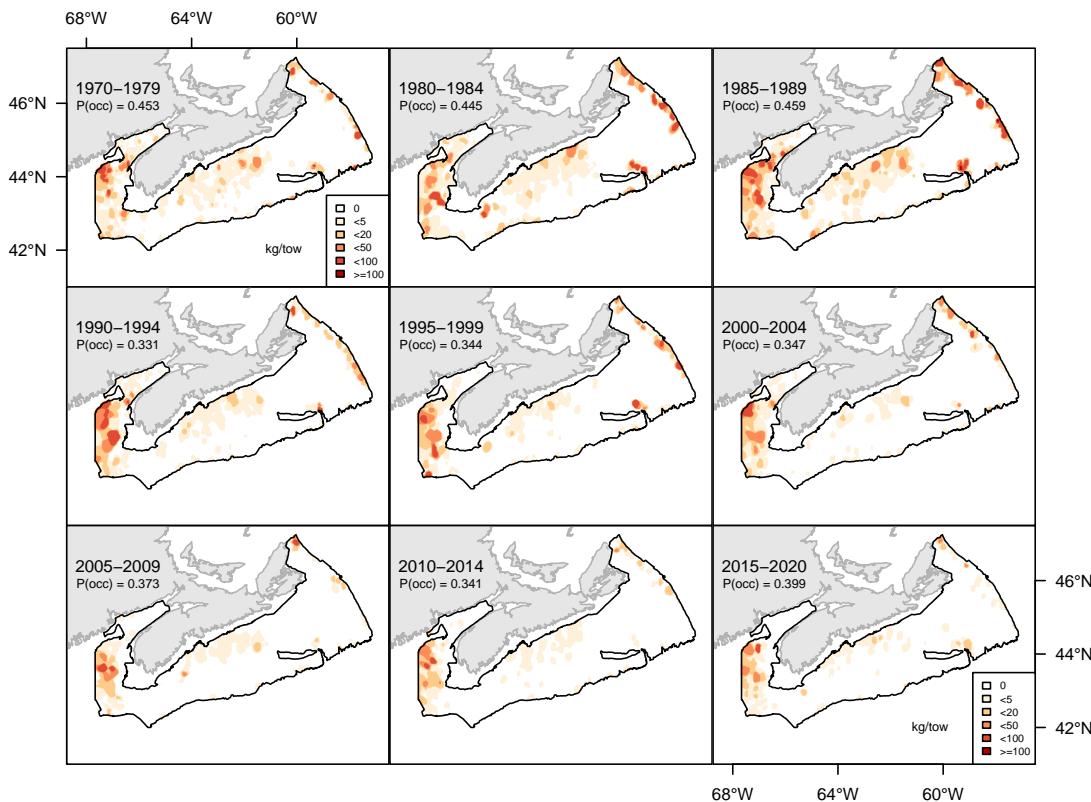


Figure 6.3A. Inverse distance weighted distribution of catch biomass (kg/tow) for White hake. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

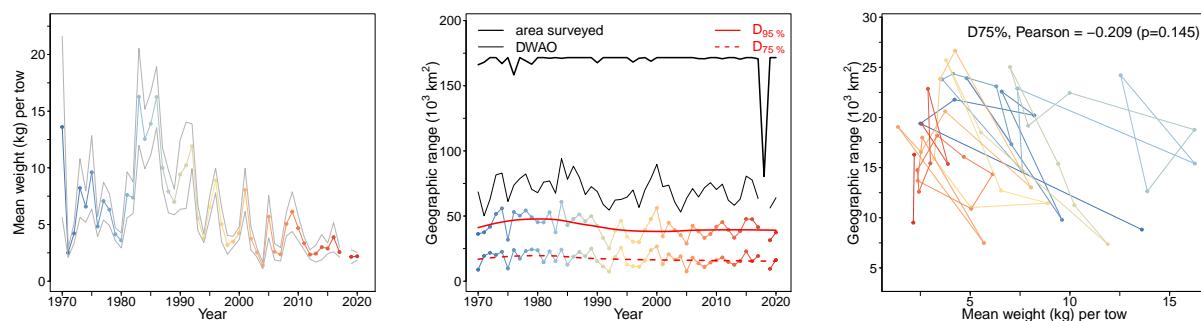


Figure 6.3B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of White hake. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

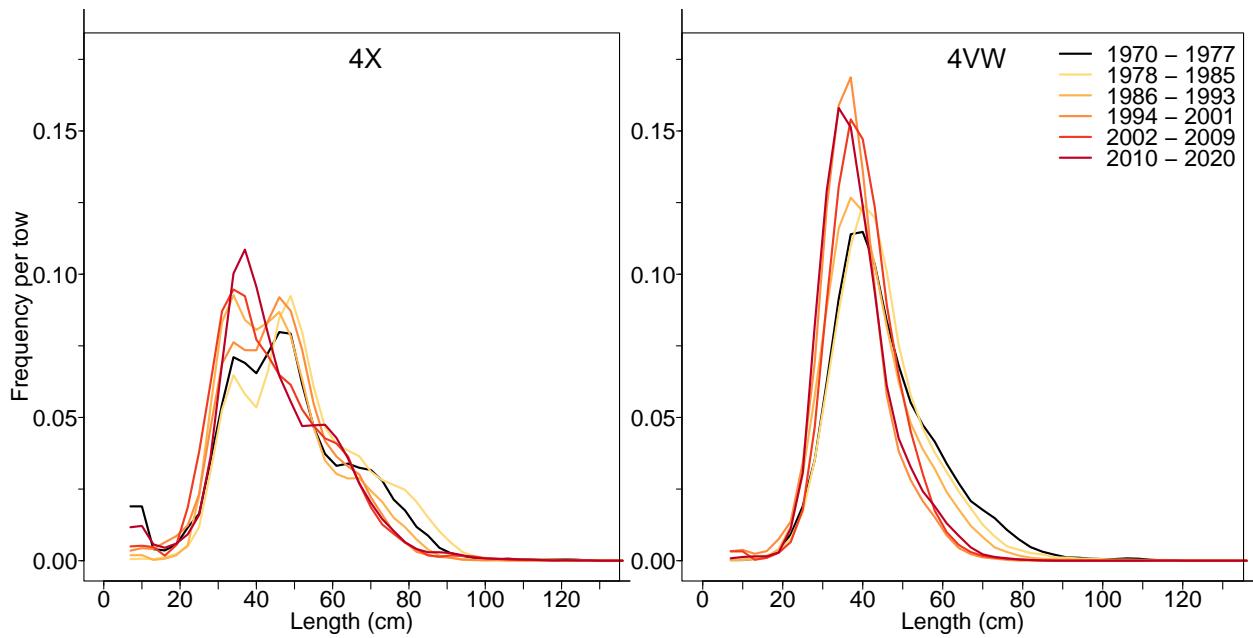


Figure 6.3C. Length frequency distribution in NAFO units 4X and 4VW for White hake.

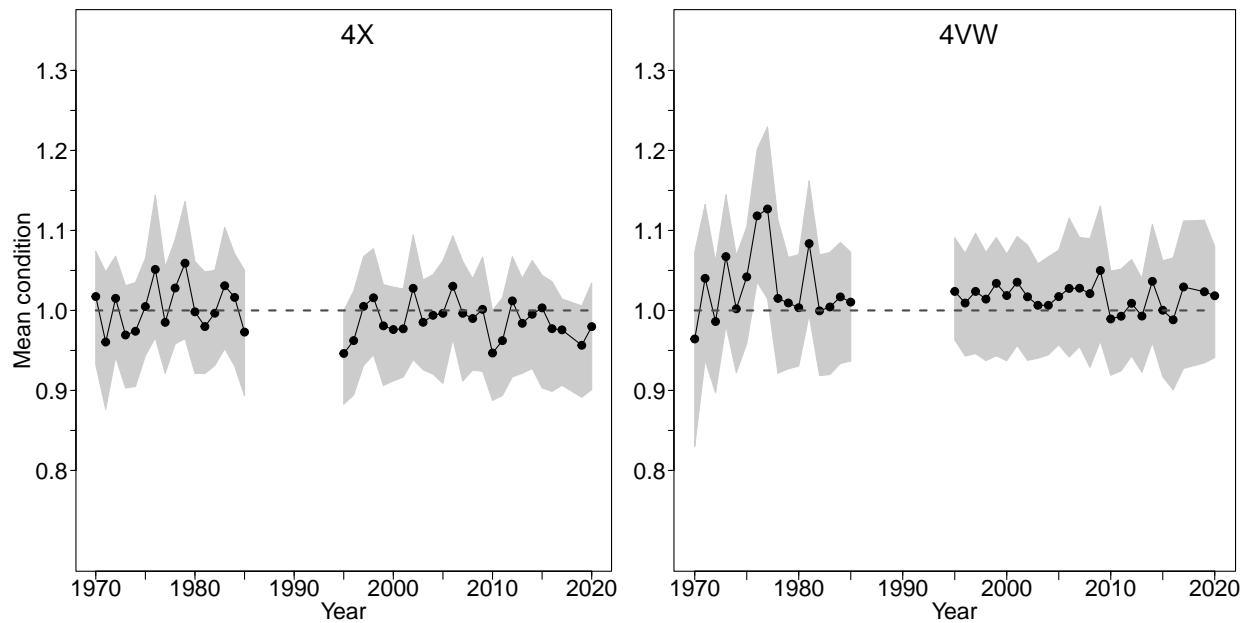


Figure 6.3D. Average fish condition in NAFO units 4X and 4VW for White hake.

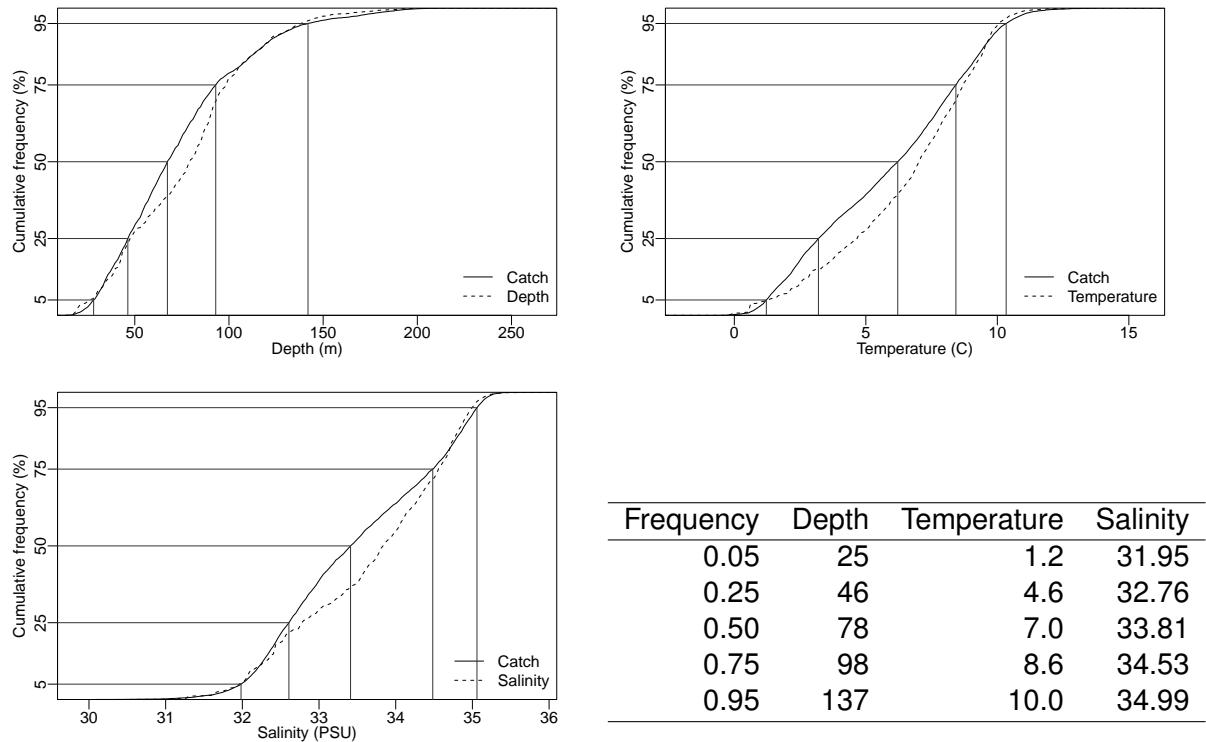


Figure 6.3E. Catch distribution by depth, temperature and salinity of White hake.

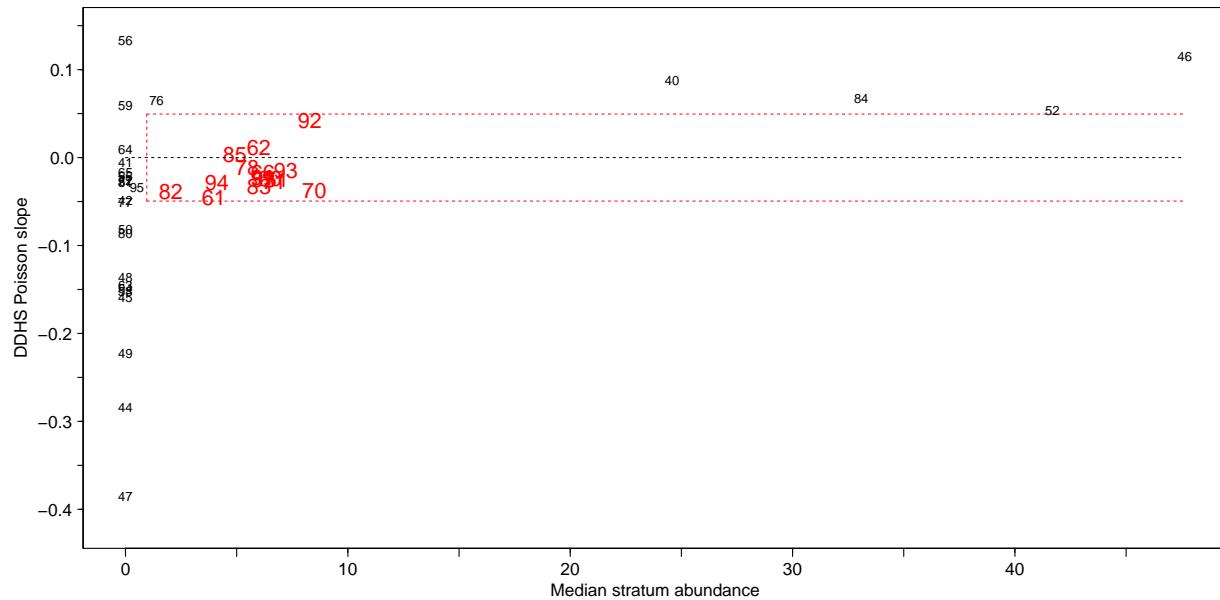


Figure 6.3F. DDHS slopes versus median stratum abundance for White hake. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.4 Red hake (Merluche écureuil) - species code 13 (category LF)

Scientific name: [*Urophycis chuss*](#)

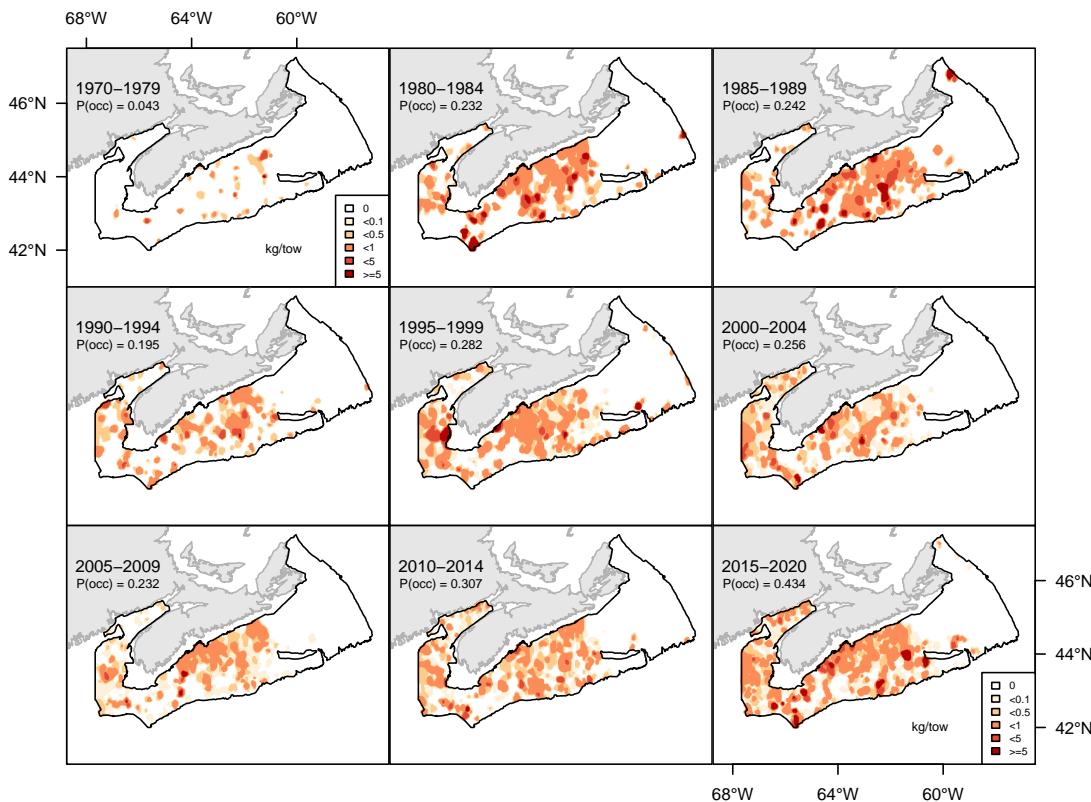


Figure 6.4A. Inverse distance weighted distribution of catch biomass (kg/tow) for Red hake. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

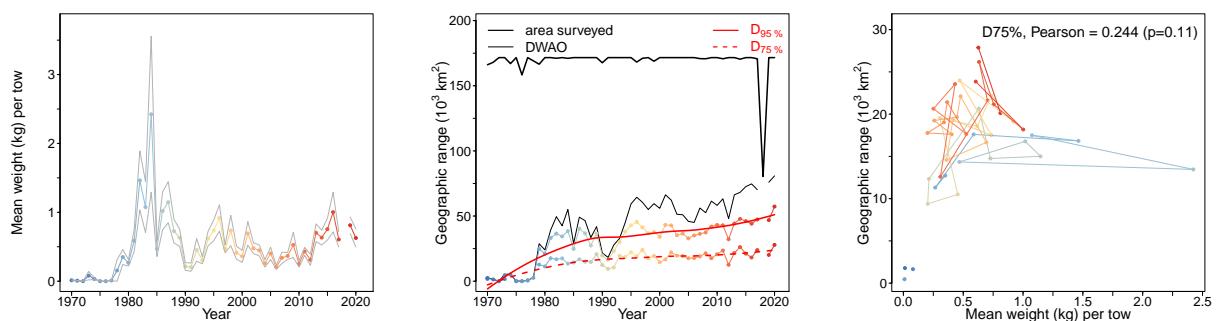


Figure 6.4B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Red hake. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

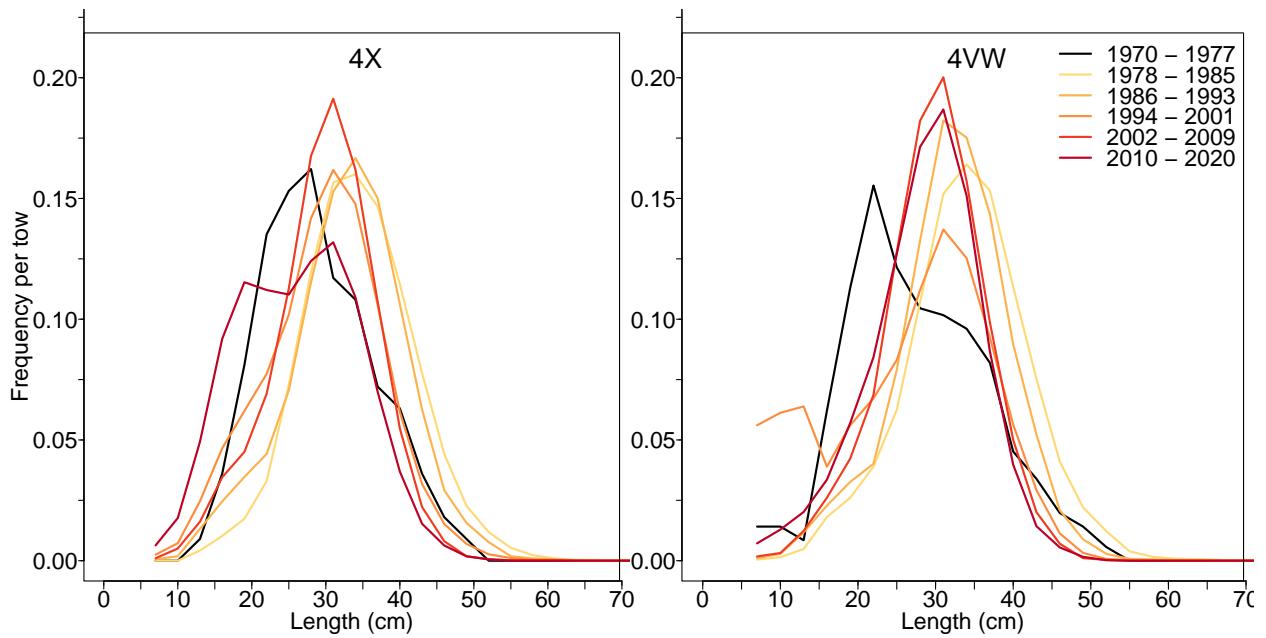


Figure 6.4C. Length frequency distribution in NAFO units 4X and 4VW for Red hake.

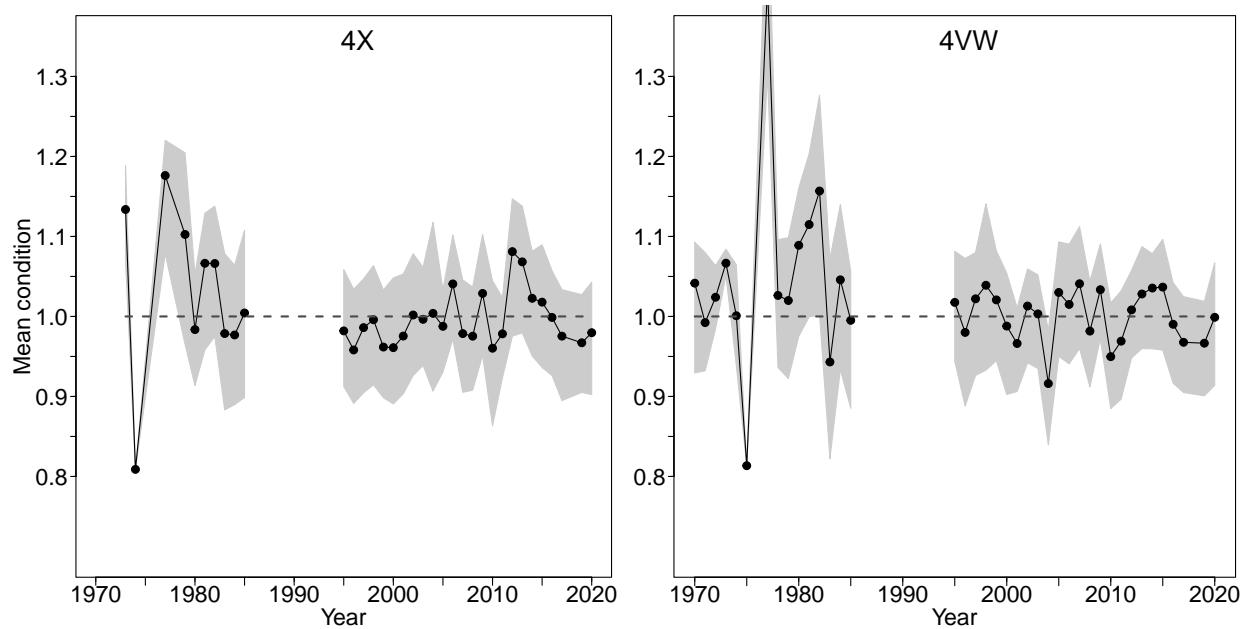


Figure 6.4D. Average fish condition in NAFO units 4X and 4VW for Red hake.

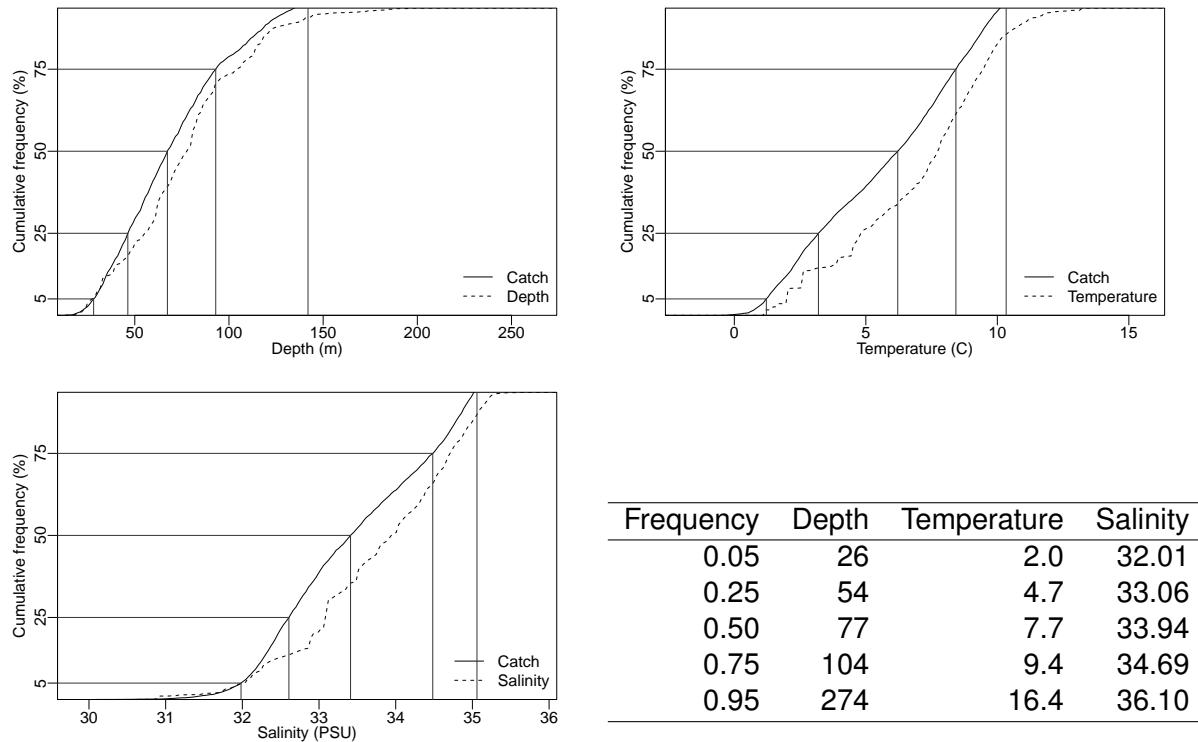


Figure 6.4E. Catch distribution by depth, temperature and salinity of Red hake.

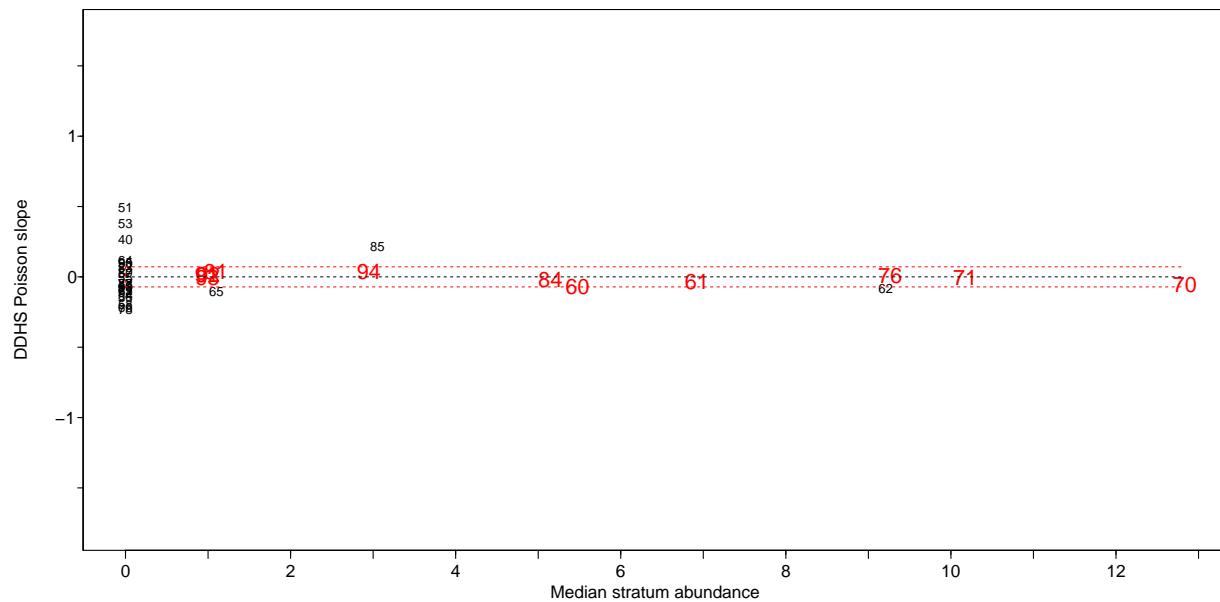


Figure 6.4F. DDHS slopes versus median stratum abundance for Red hake. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.5 Silver hake (*Merlu argenté*) - species code 14 (category LF)

Scientific name: [Merluccius bilinearis](#)

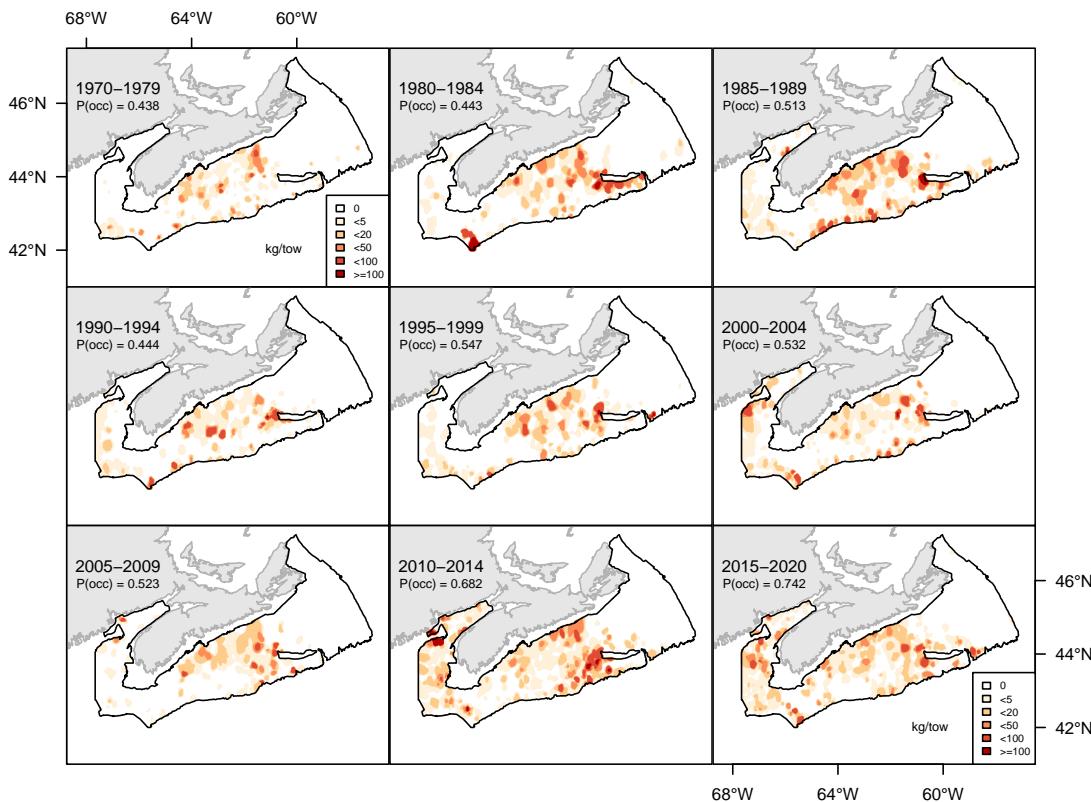


Figure 6.5A. Inverse distance weighted distribution of catch biomass (kg/tow) for Silver hake. $P(\text{occ})$ is the proportion of tugs with catch records for each 5-year period.

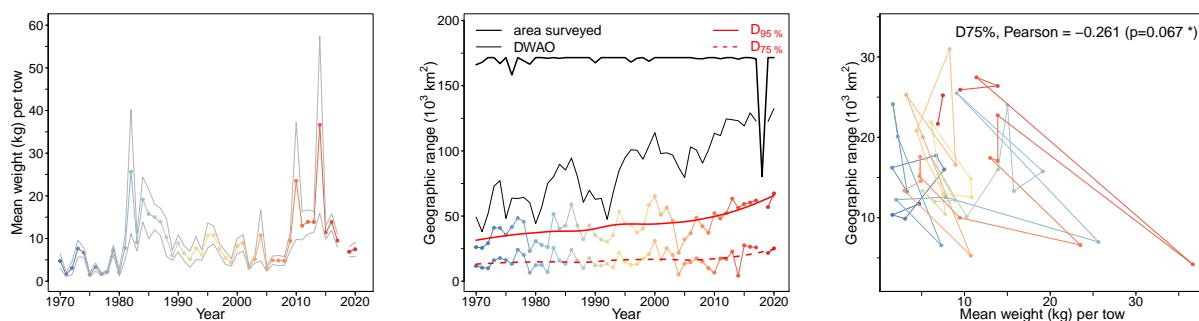


Figure 6.5B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Silver hake. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

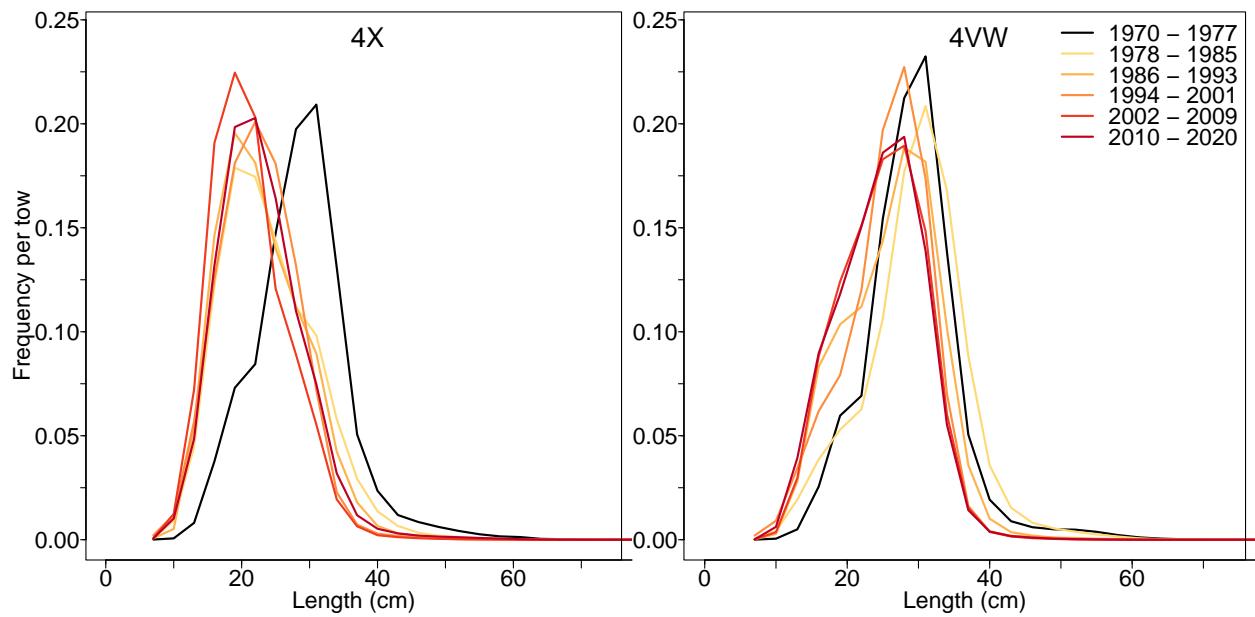


Figure 6.5C. Length frequency distribution in NAFO units 4X and 4VW for Silver hake.

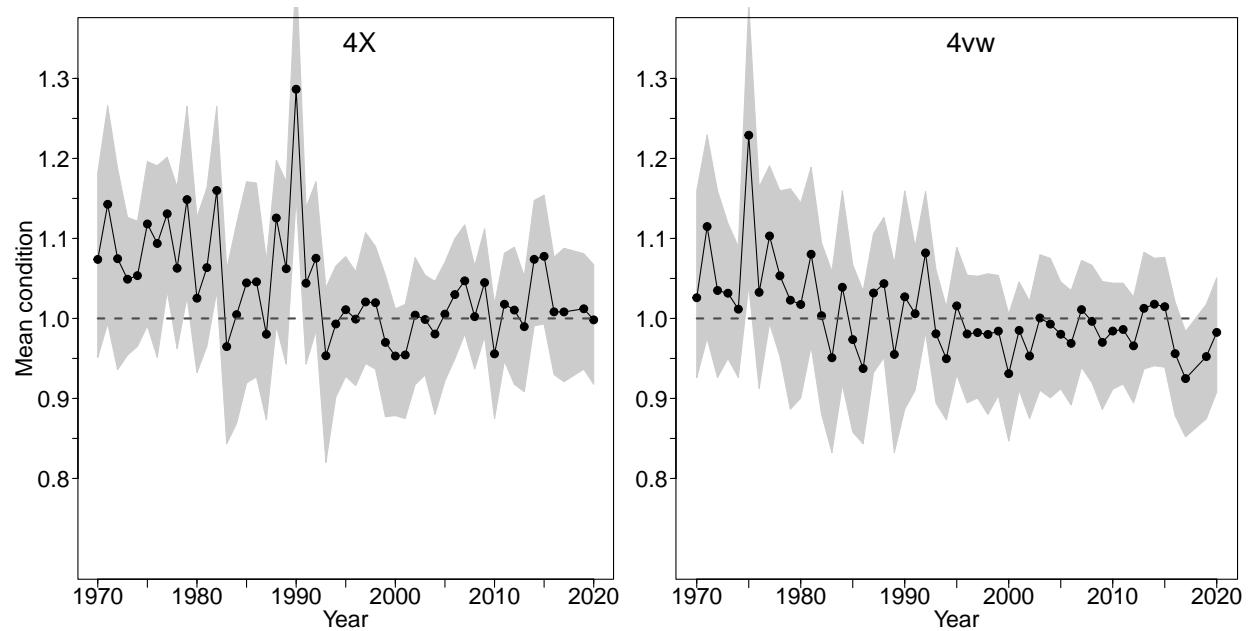


Figure 6.5D. Average fish condition in NAFO units 4X and 4VW for Silver hake.

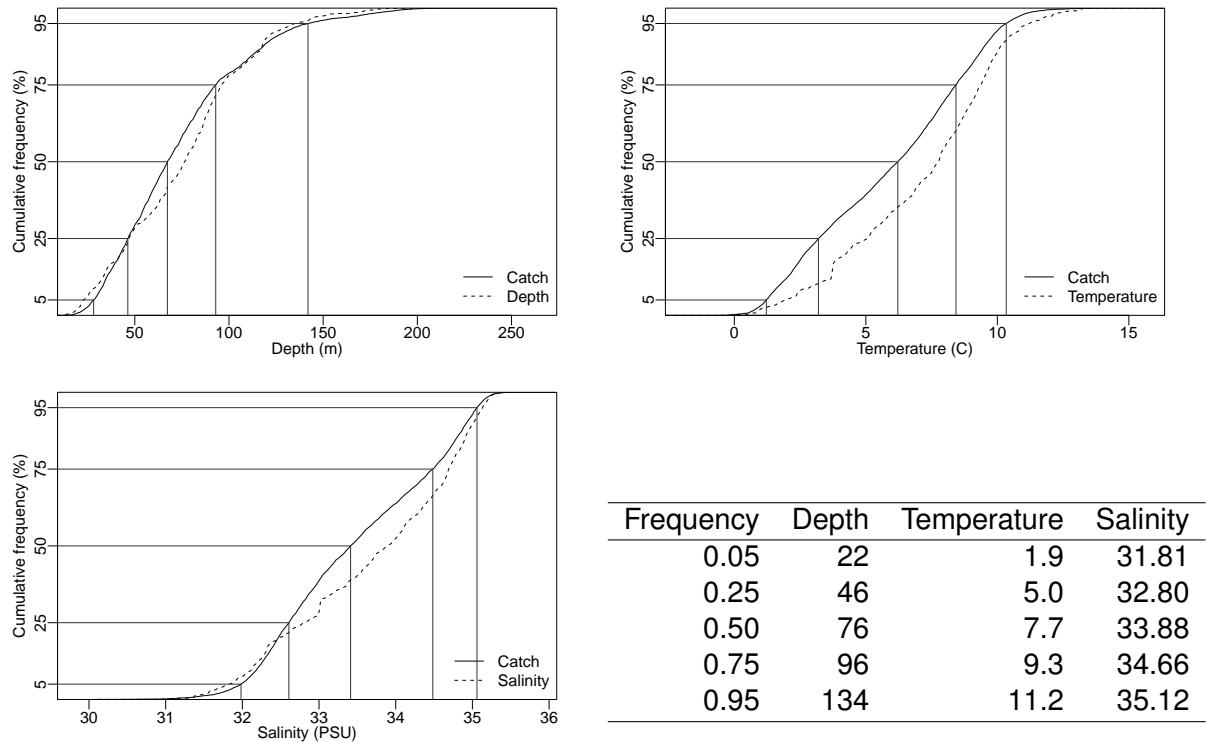


Figure 6.5E. Catch distribution by depth, temperature and salinity of Silver hake.

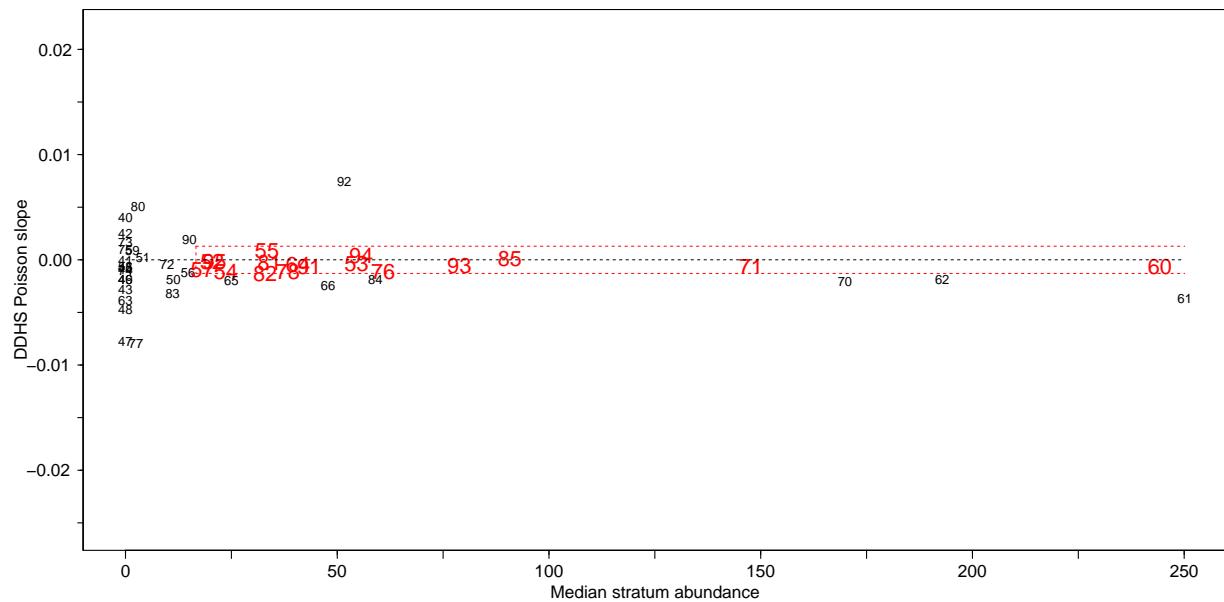


Figure 6.5F. DDHS slopes versus median stratum abundance for Silver hake. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.6 Pollock (Goberge) - species code 16 (category LF)

Scientific name: [Pollachius virens](#)

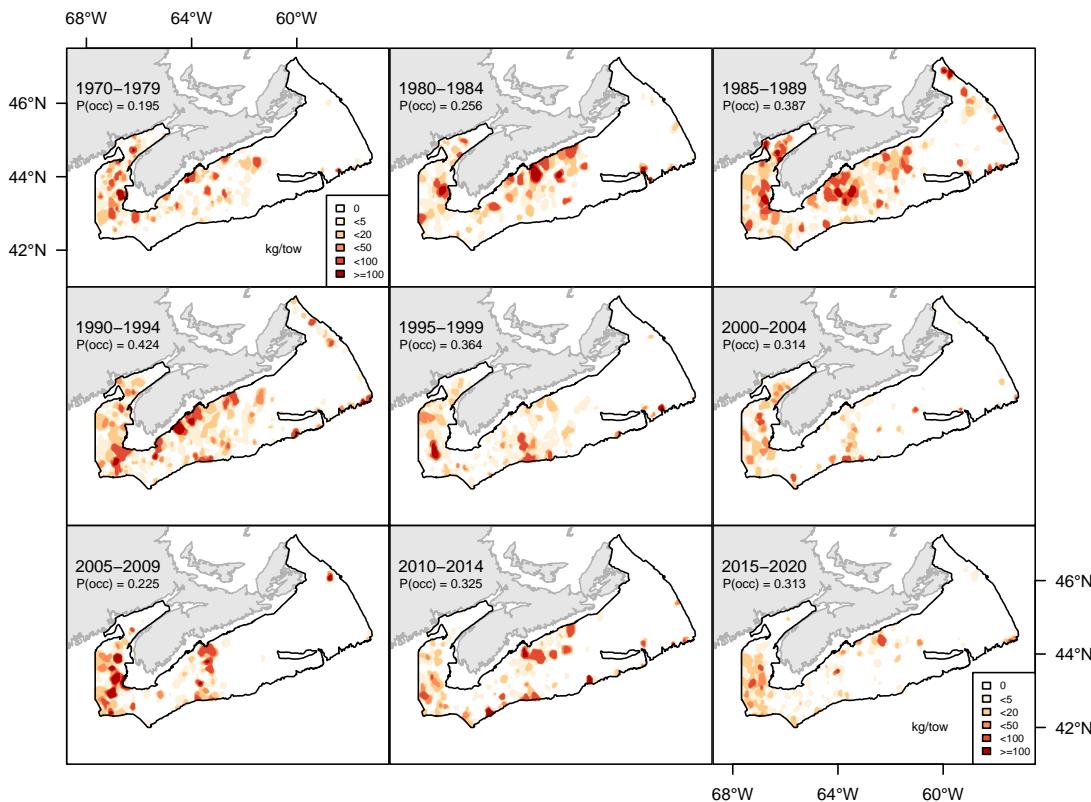


Figure 6.6A. Inverse distance weighted distribution of catch biomass (kg/tow) for Pollock. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

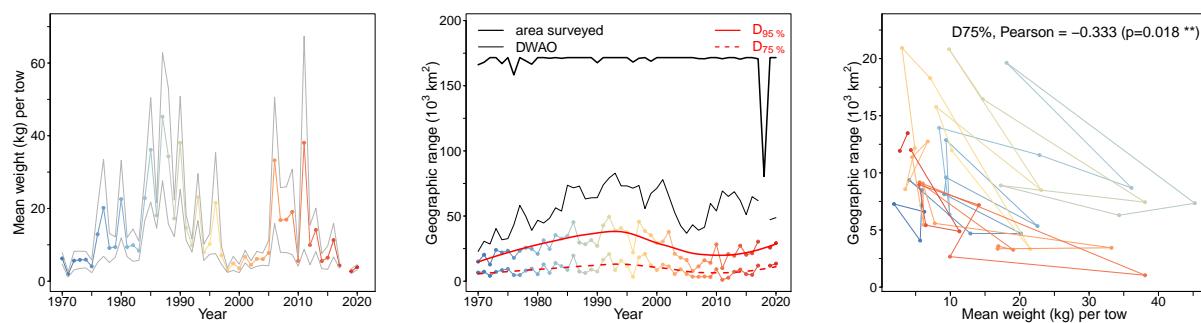


Figure 6.6B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Pollock. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

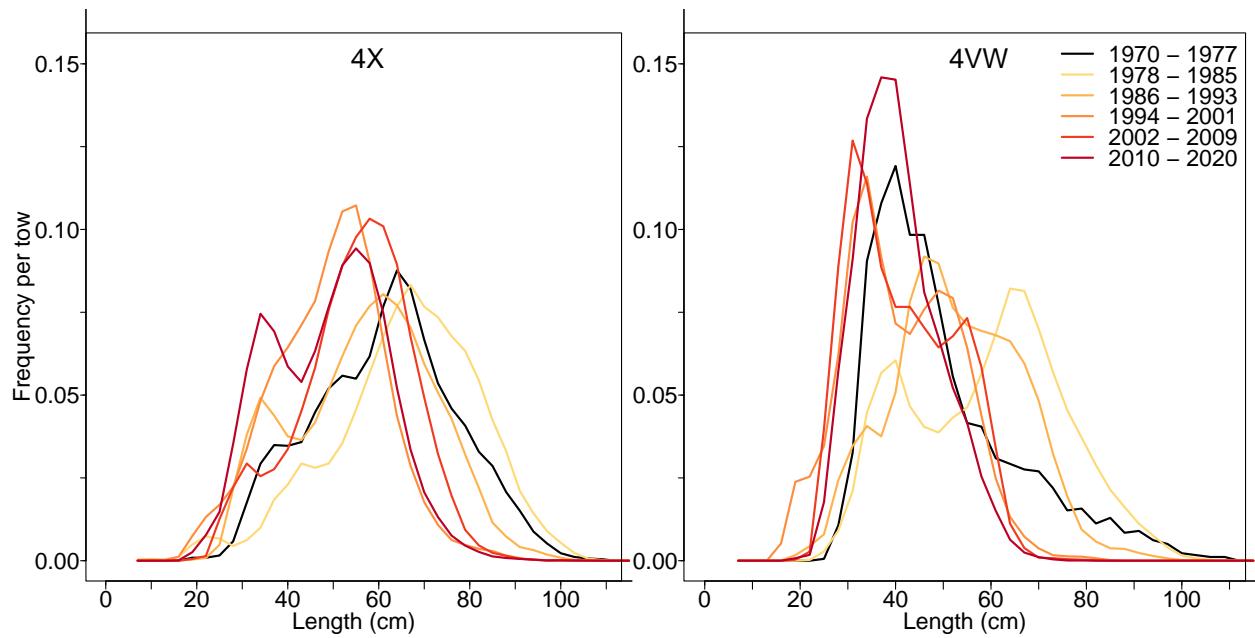


Figure 6.6C. Length frequency distribution in NAFO units 4X and 4VW for Pollock.

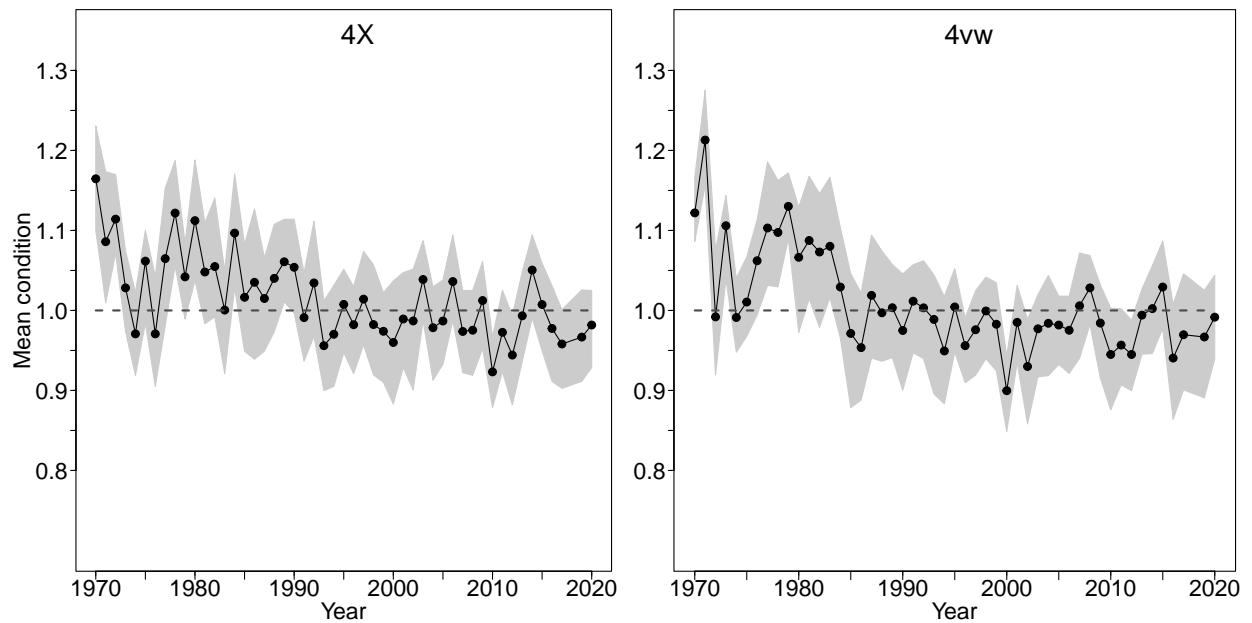


Figure 6.6D. Average fish condition in NAFO units 4X and 4VW for Pollock.

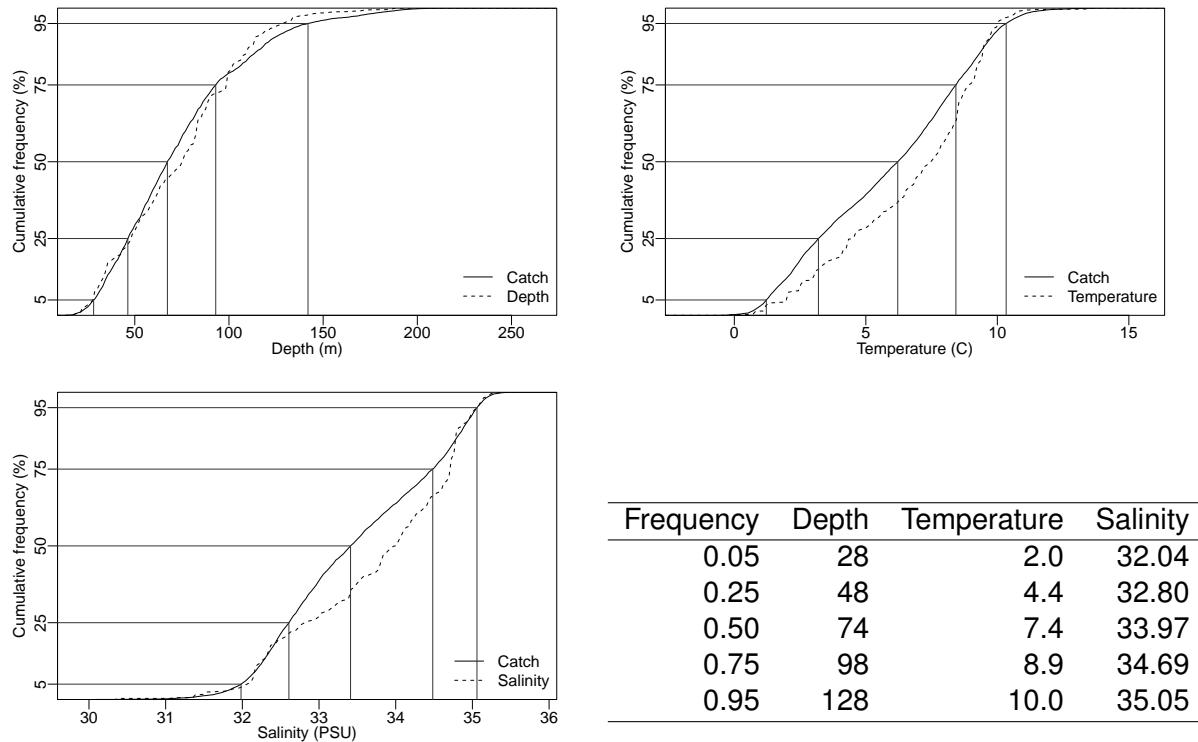


Figure 6.6E. Catch distribution by depth, temperature and salinity of Pollock.

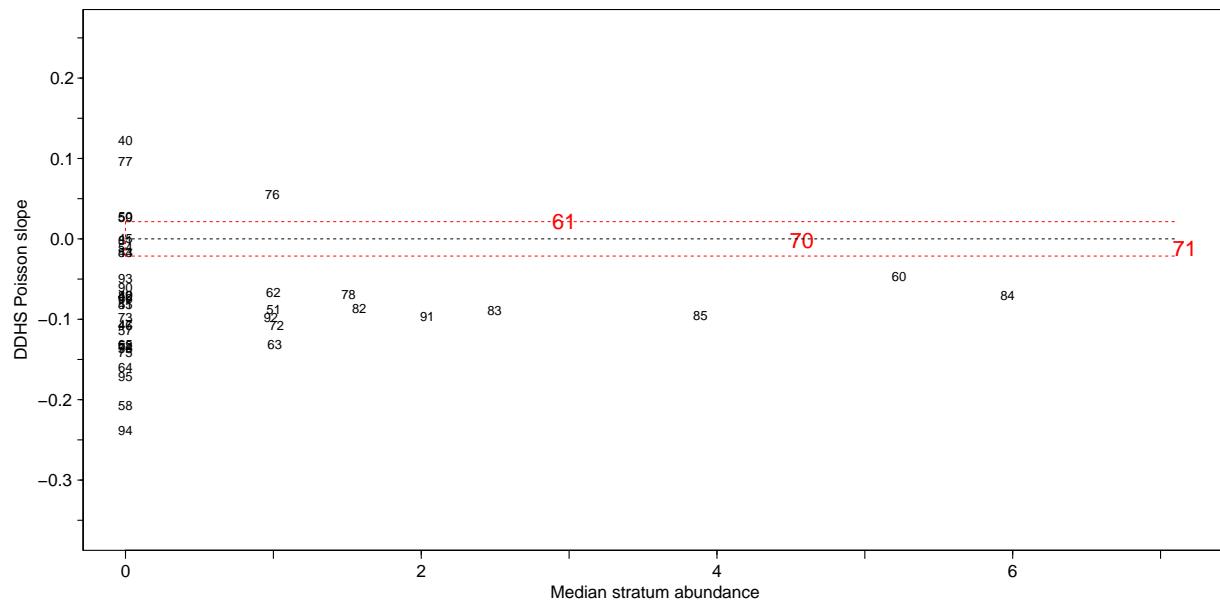


Figure 6.6F. DDHS slopes versus median stratum abundance for Pollock. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.7 Sea raven (Hémithriptère atlantique) - species code 320 (category LF)

Scientific name: [Hemitripterus americanus](#)

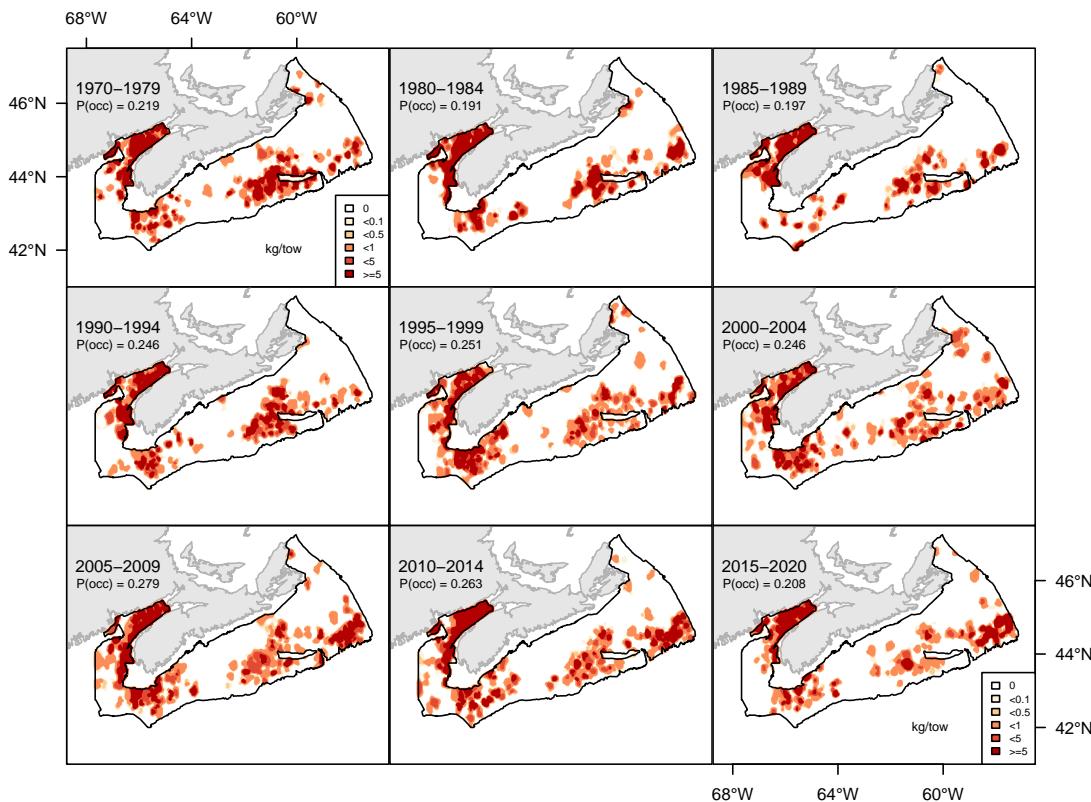


Figure 6.7A. Inverse distance weighted distribution of catch biomass (kg/tow) for Sea raven. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

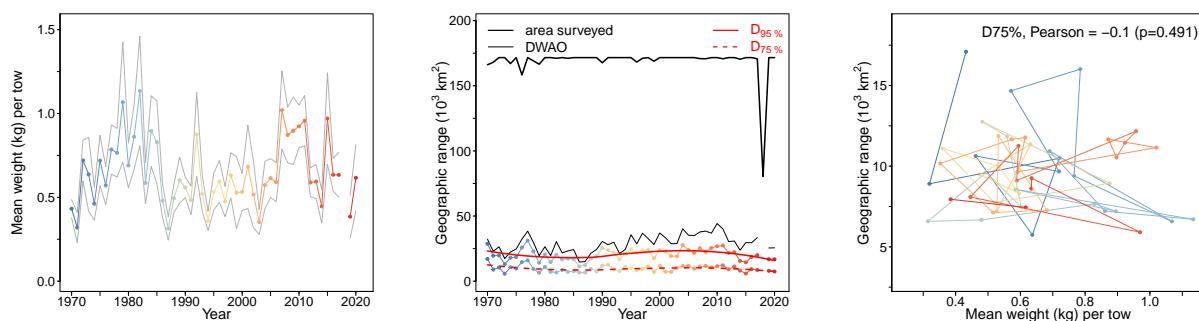


Figure 6.7B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sea raven. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

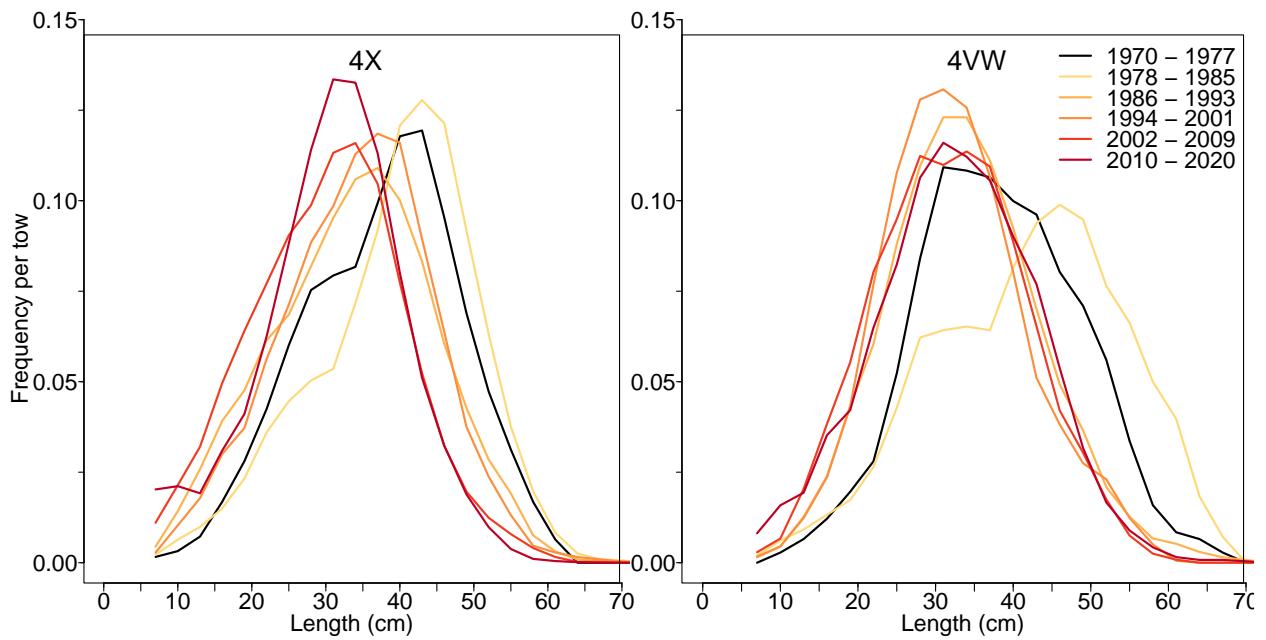


Figure 6.7C. Length frequency distribution in NAFO units 4X and 4VW for Sea raven.

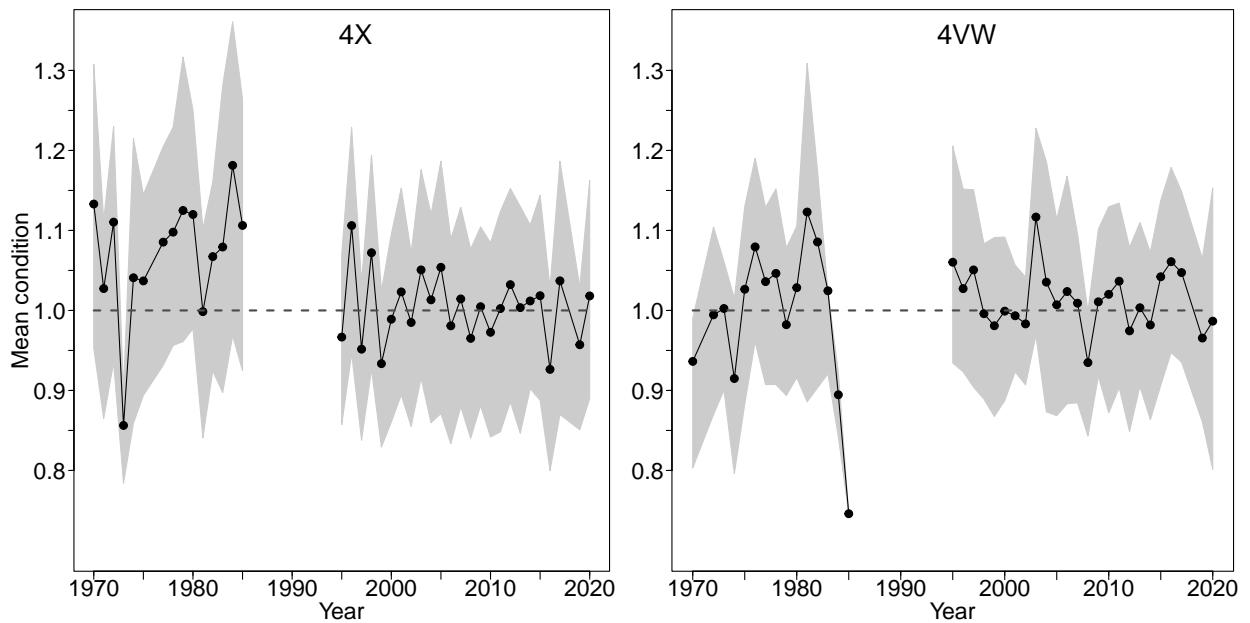


Figure 6.7D. Average fish condition in NAFO units 4X and 4VW for Sea raven.

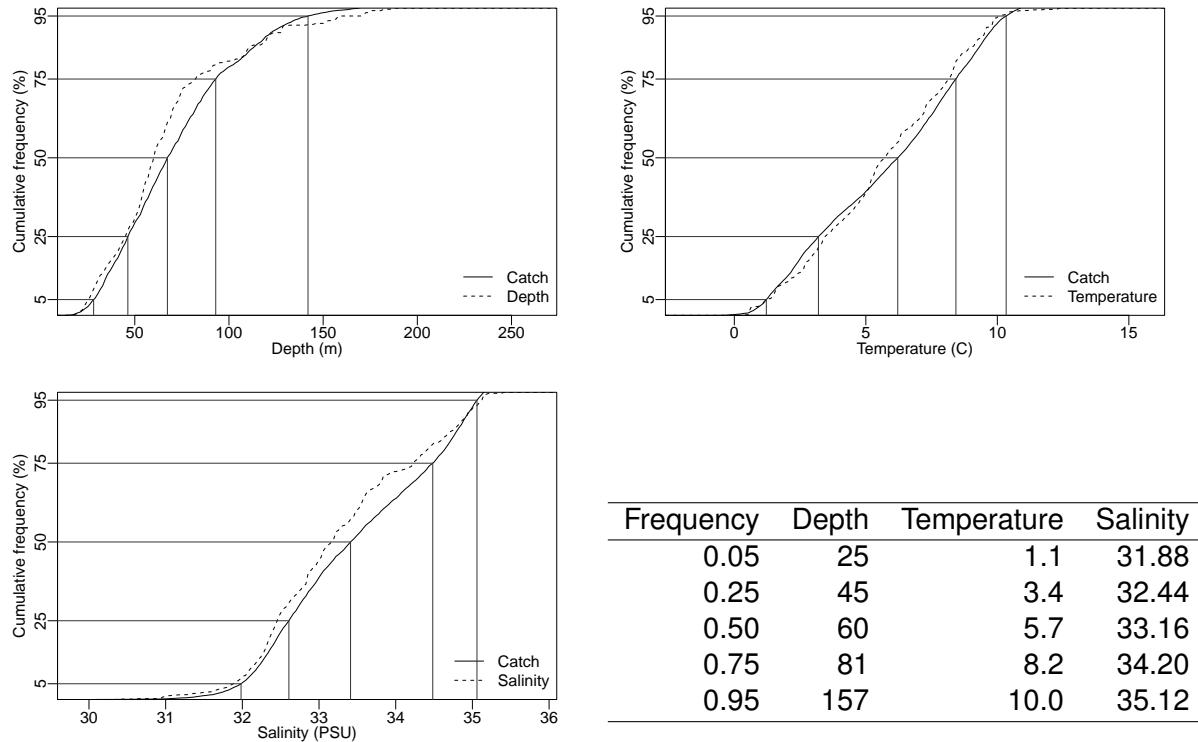


Figure 6.7E. Catch distribution by depth, temperature and salinity of Sea raven.

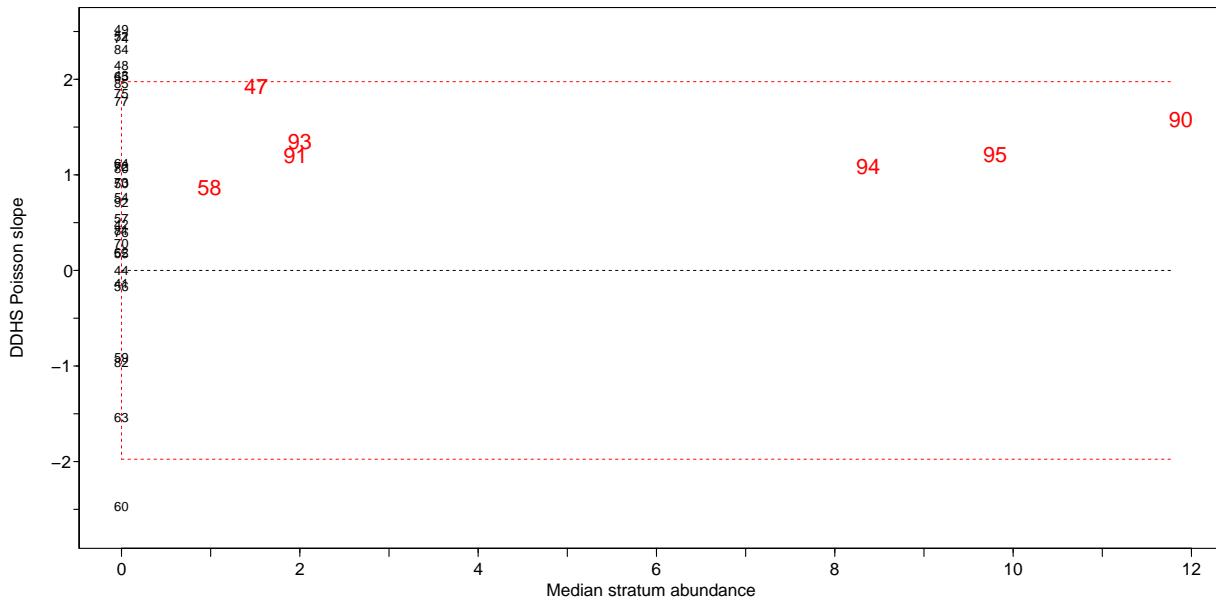


Figure 6.7F. DDHS slopes versus median stratum abundance for Sea raven. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.8 Atlantic halibut (Flétan de l'Atlantique) - species code 30 (category LF)

Scientific name: [Hippoglossus hippoglossus](#)

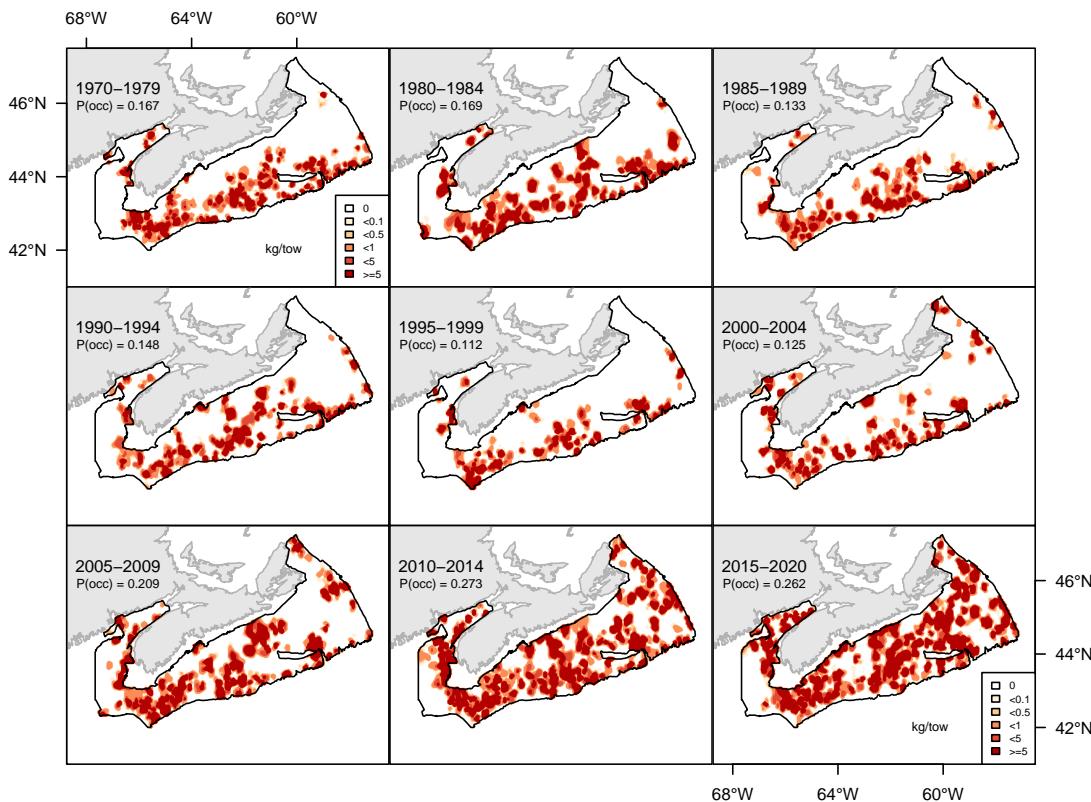


Figure 6.8A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic halibut. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

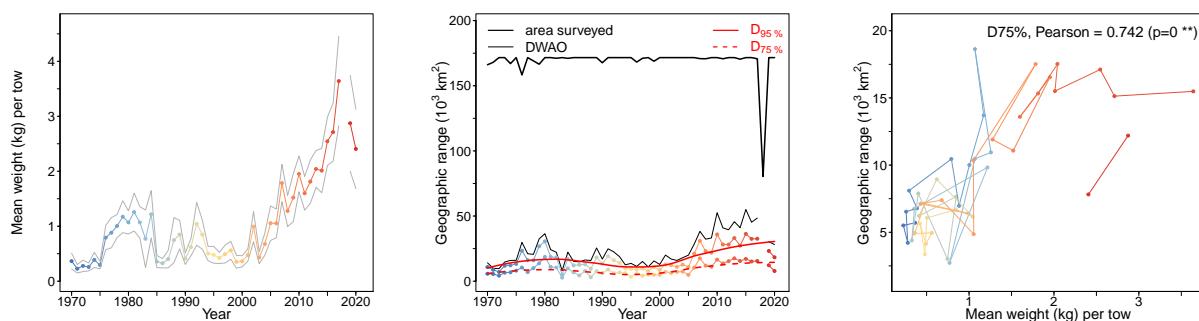


Figure 6.8B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic halibut. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

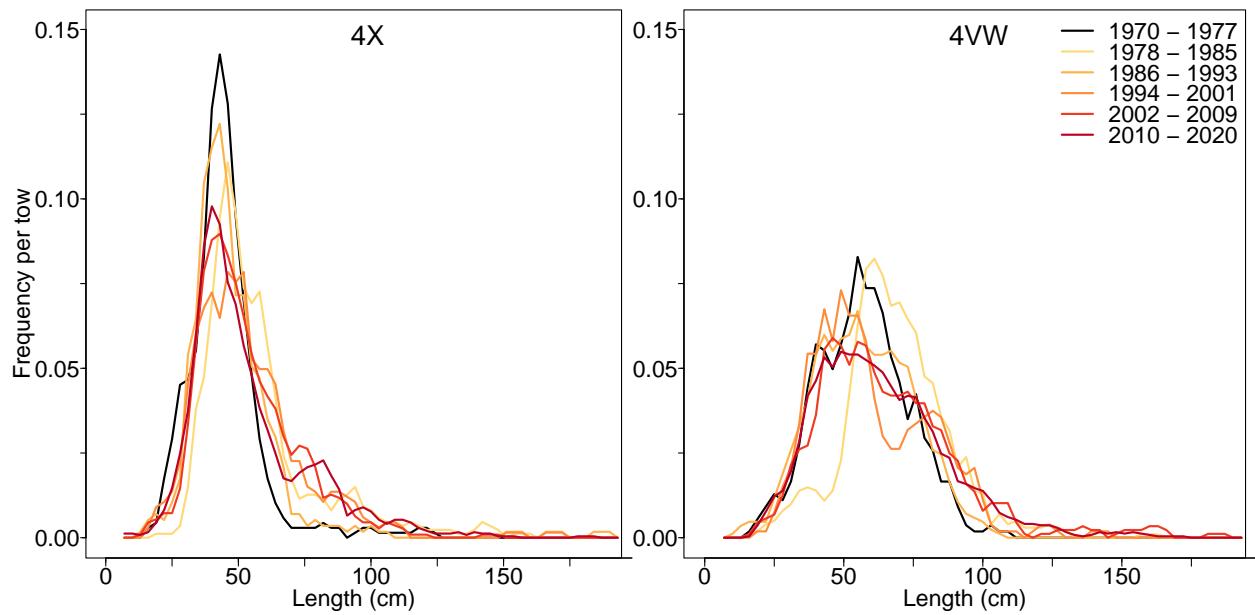


Figure 6.8C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic halibut.

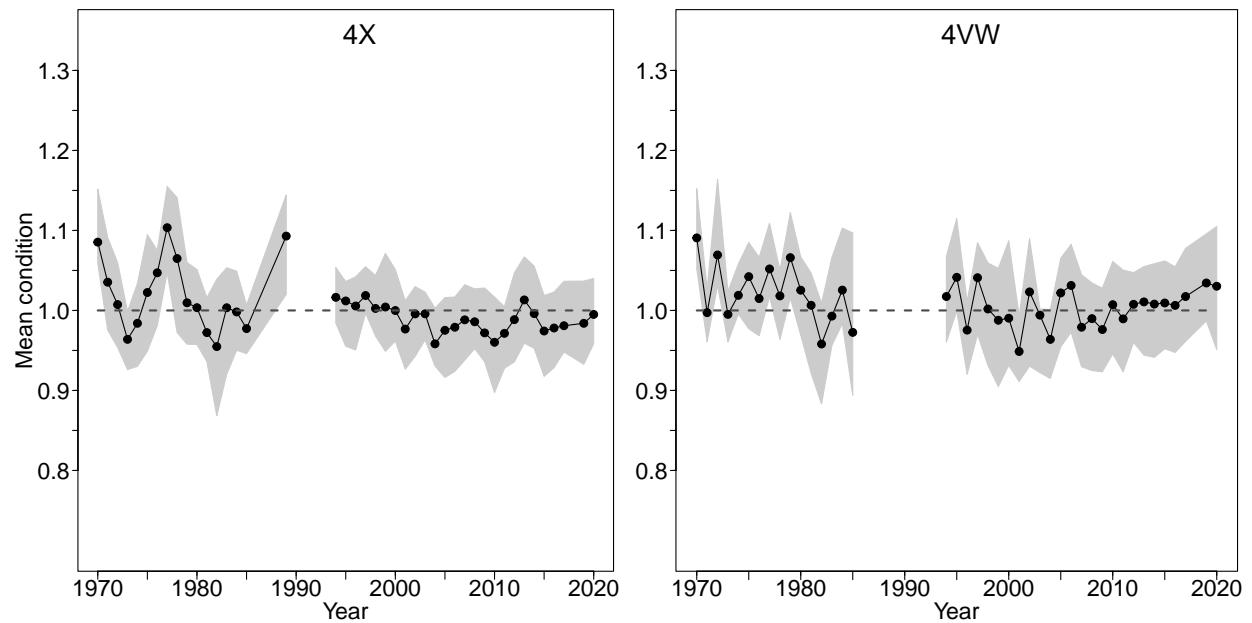


Figure 6.8D. Average fish condition in NAFO units 4X and 4VW for Atlantic halibut.

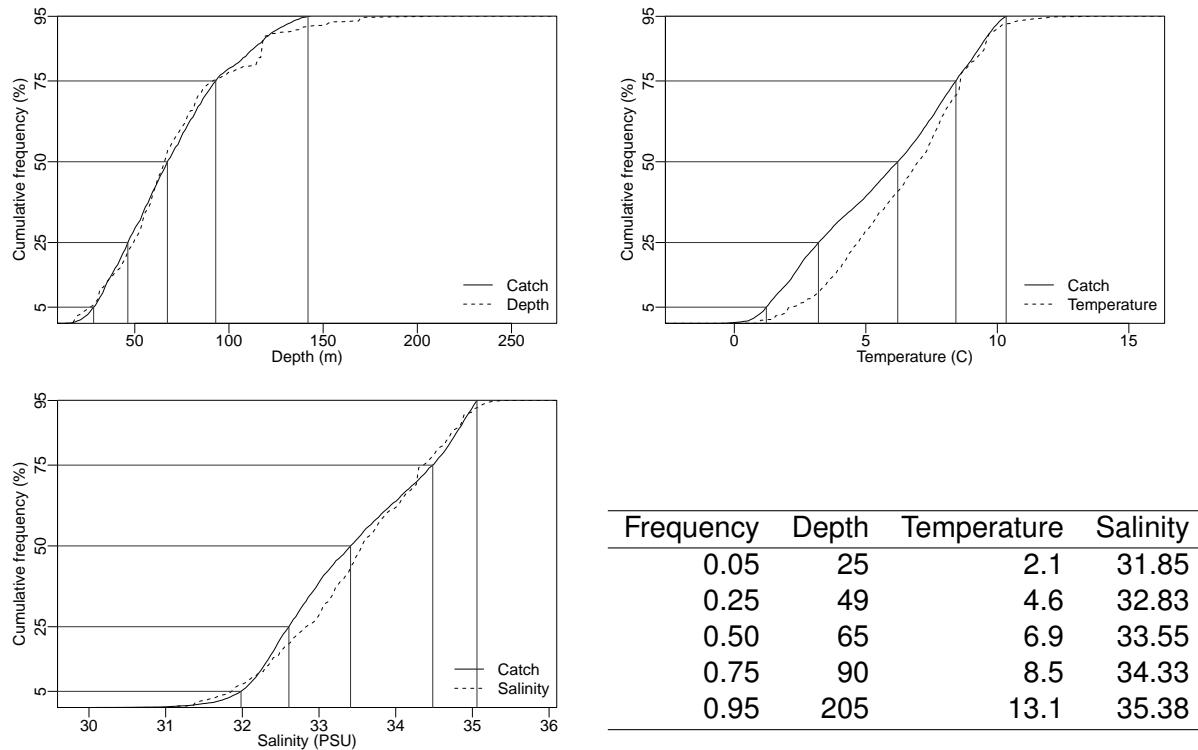


Figure 6.8E. Catch distribution by depth, temperature and salinity of Atlantic halibut.

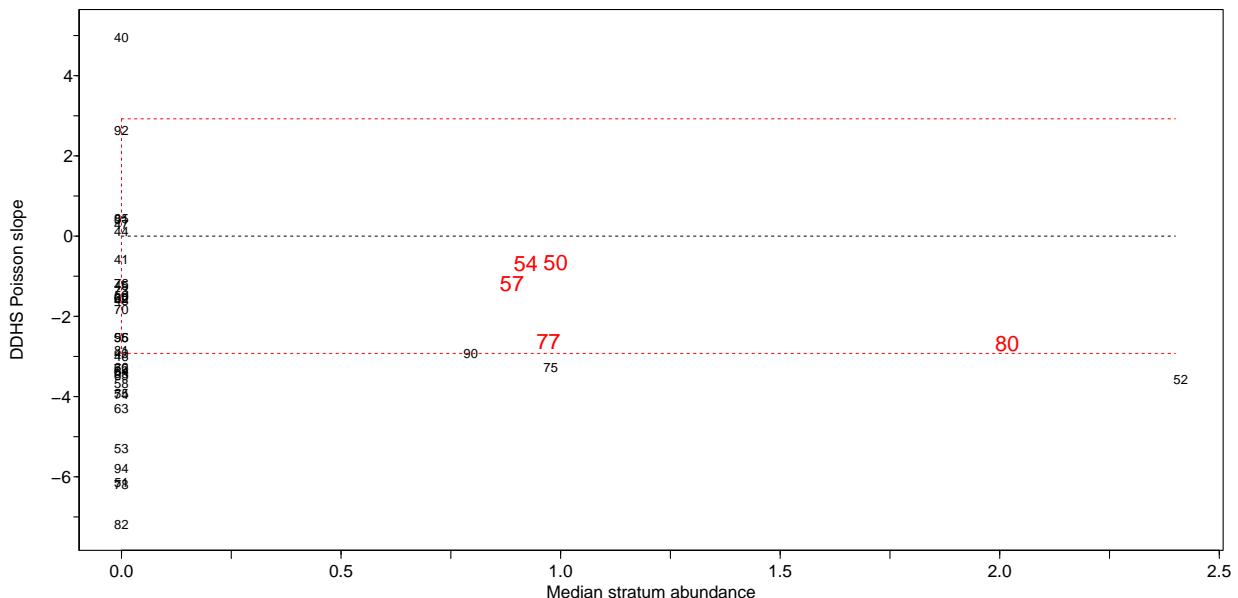


Figure 6.8F. DDHS slopes versus median stratum abundance for Atlantic halibut. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.9 American plaice (Plie canadienne) - species code 40 (category LF)

Scientific name: [Hippoglossoides platessoides](#)

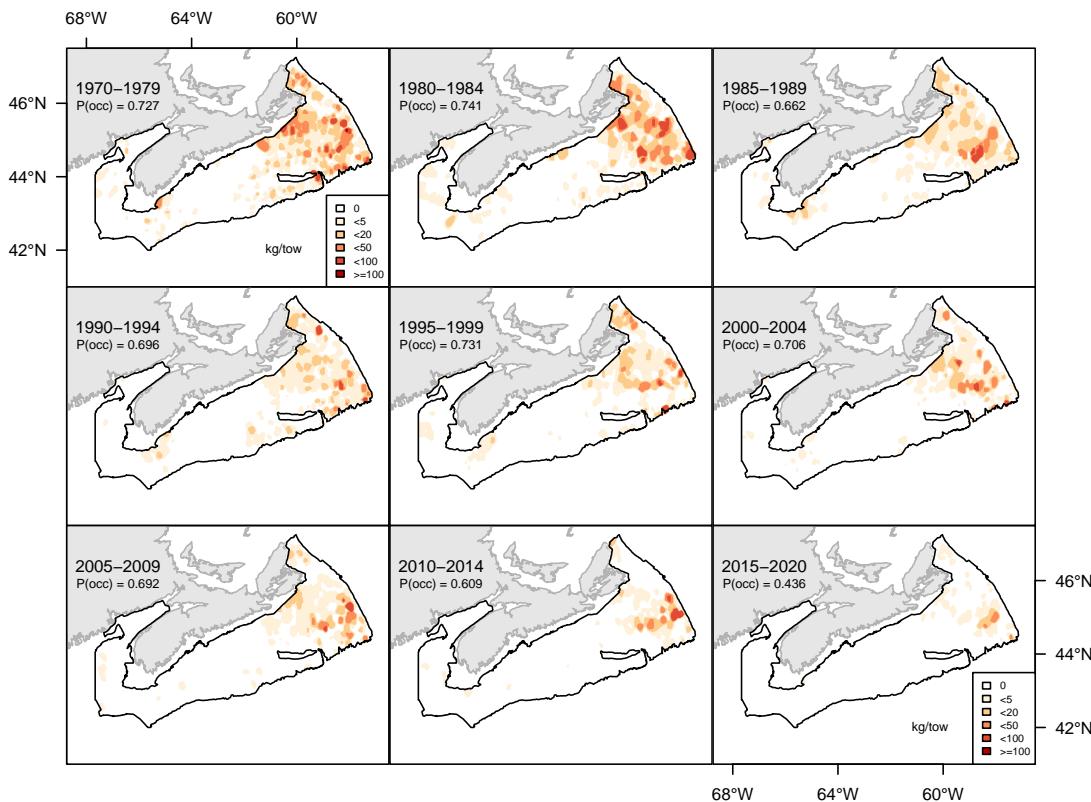


Figure 6.9A. Inverse distance weighted distribution of catch biomass (kg/tow) for American plaice. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

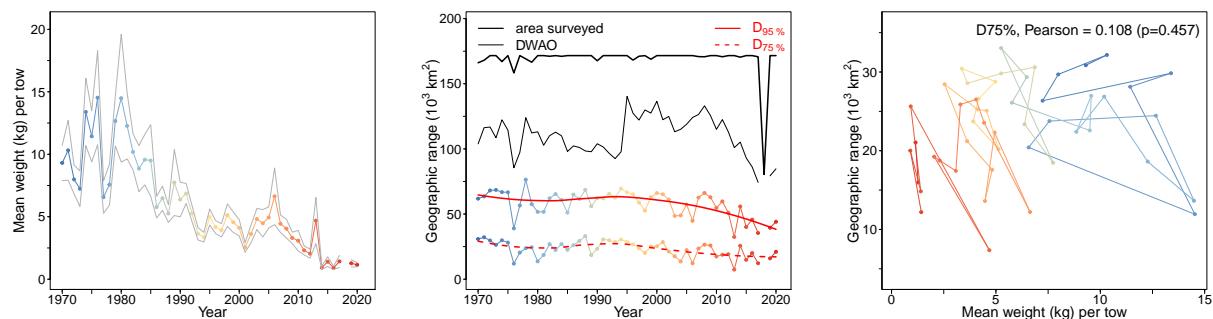


Figure 6.9B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American plaice. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

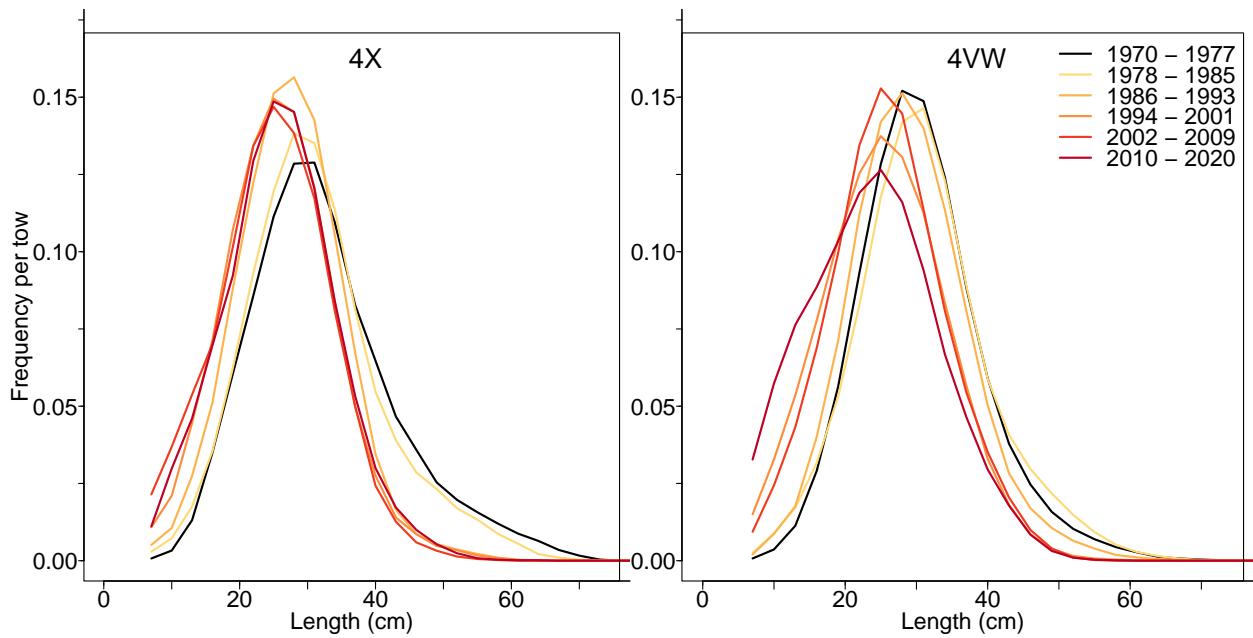


Figure 6.9C. Length frequency distribution in NAFO units 4X and 4VW for American plaice.

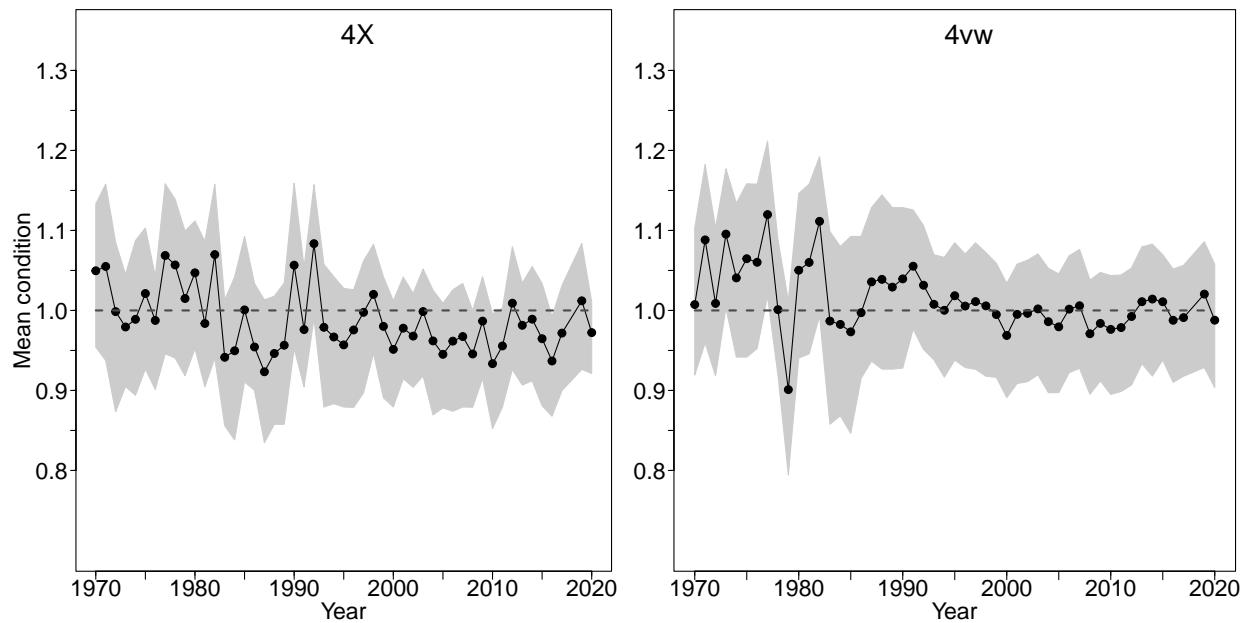


Figure 6.9D. Average fish condition in NAFO units 4X and 4VW for American plaice.

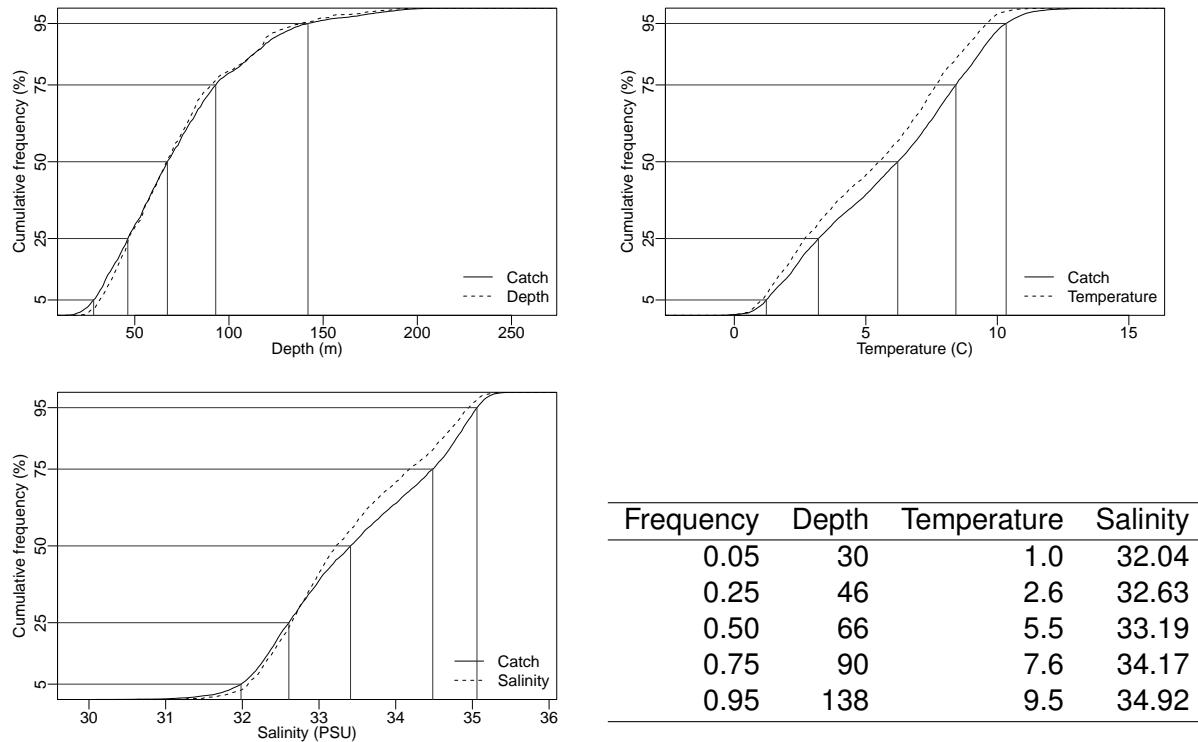


Figure 6.9E. Catch distribution by depth, temperature and salinity of American plaice.

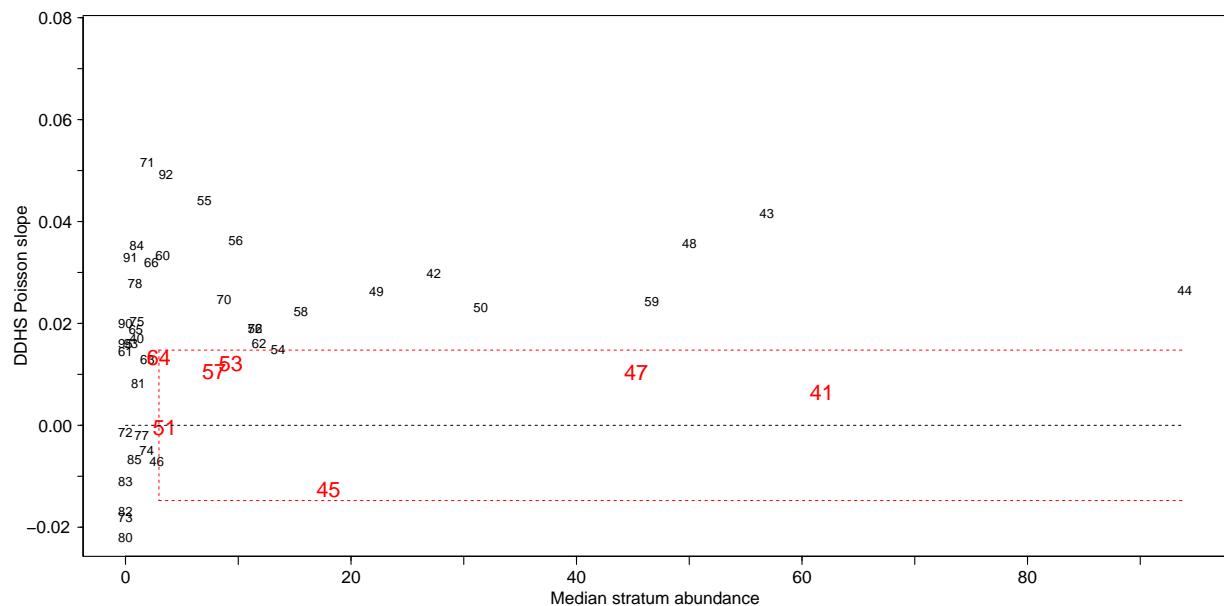


Figure 6.9F. DDHS slopes versus median stratum abundance for American plaice. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.10 Witch flounder (*Ple grise*) - species code 41 (category LF)

Scientific name: [Glyptocephalus cynoglossus](#)

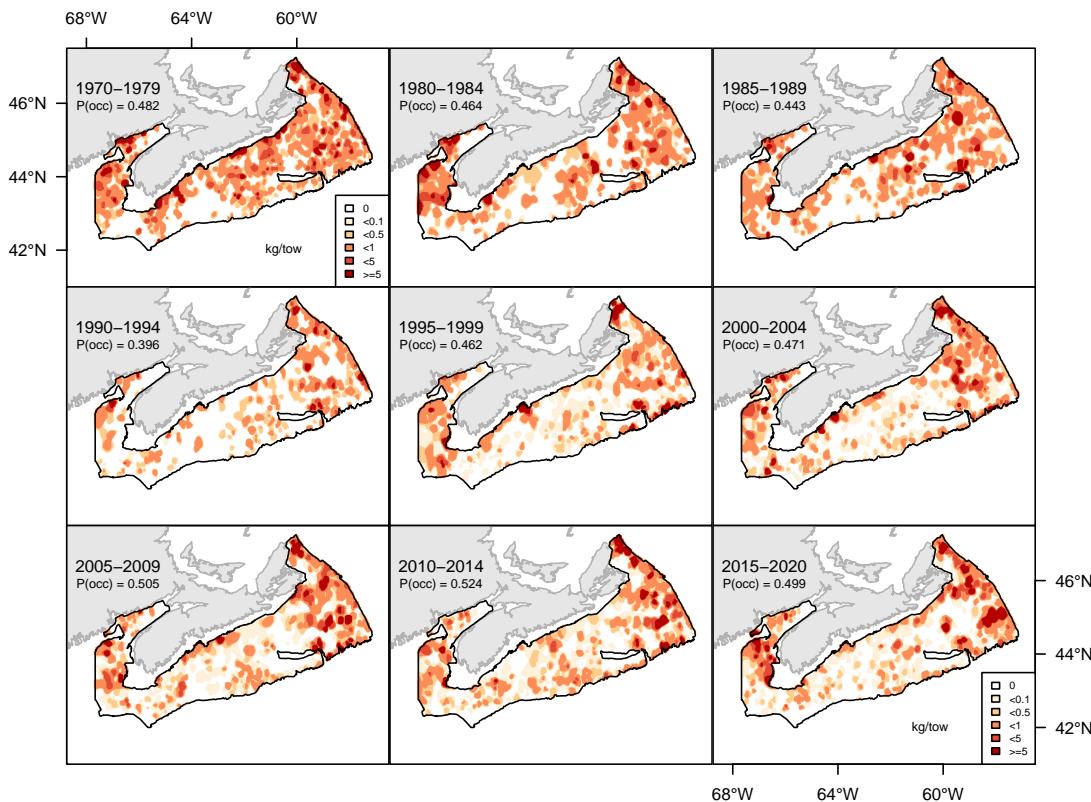


Figure 6.10A. Inverse distance weighted distribution of catch biomass (kg/tow) for Witch flounder. $P(\text{occ})$ is the proportion of tugs with catch records for each 5-year period.

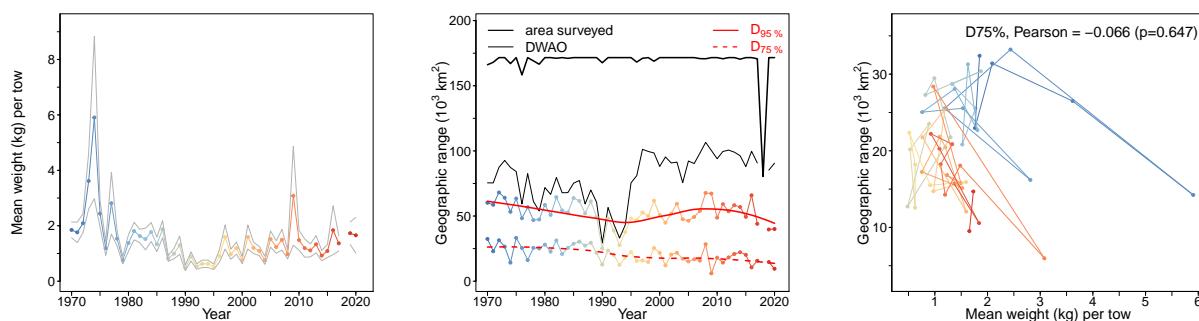


Figure 6.10B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Witch flounder. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

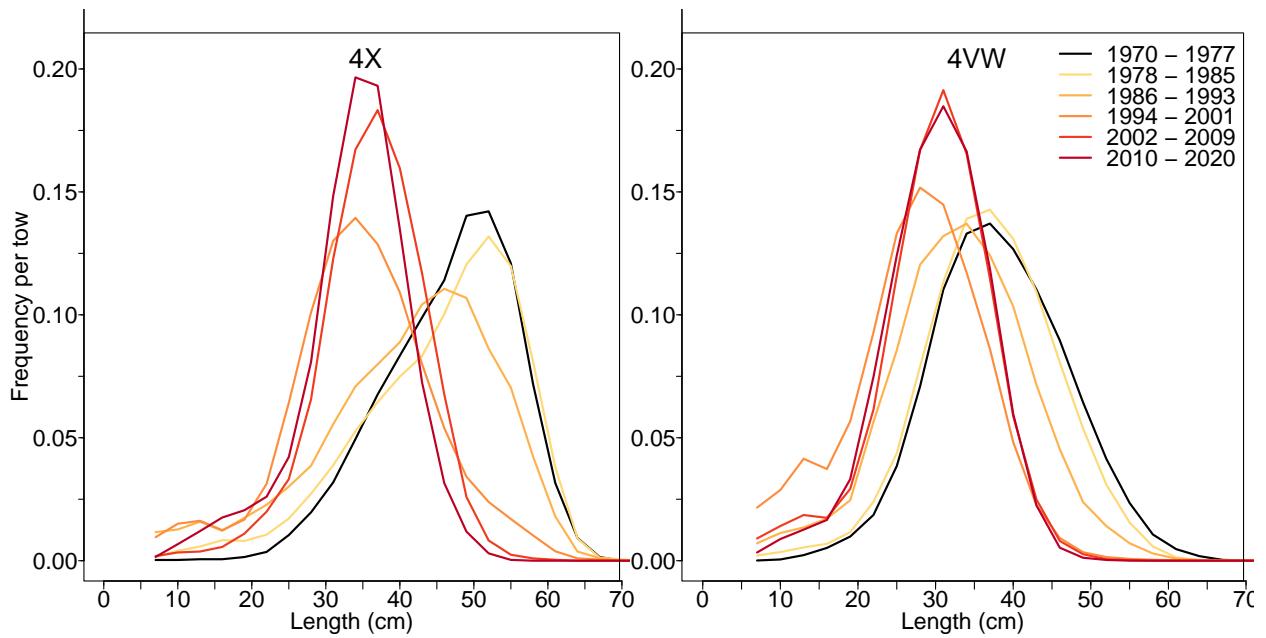


Figure 6.10C. Length frequency distribution in NAFO units 4X and 4VW for Witch flounder.

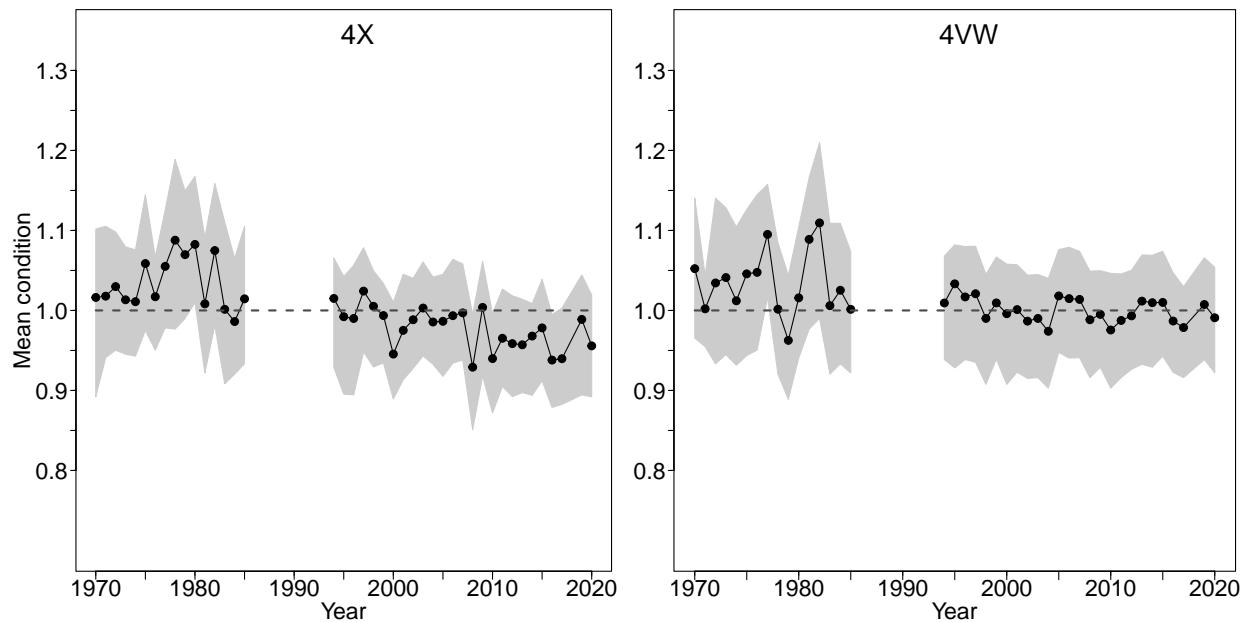


Figure 6.10D. Average fish condition in NAFO units 4X and 4VW for Witch flounder.

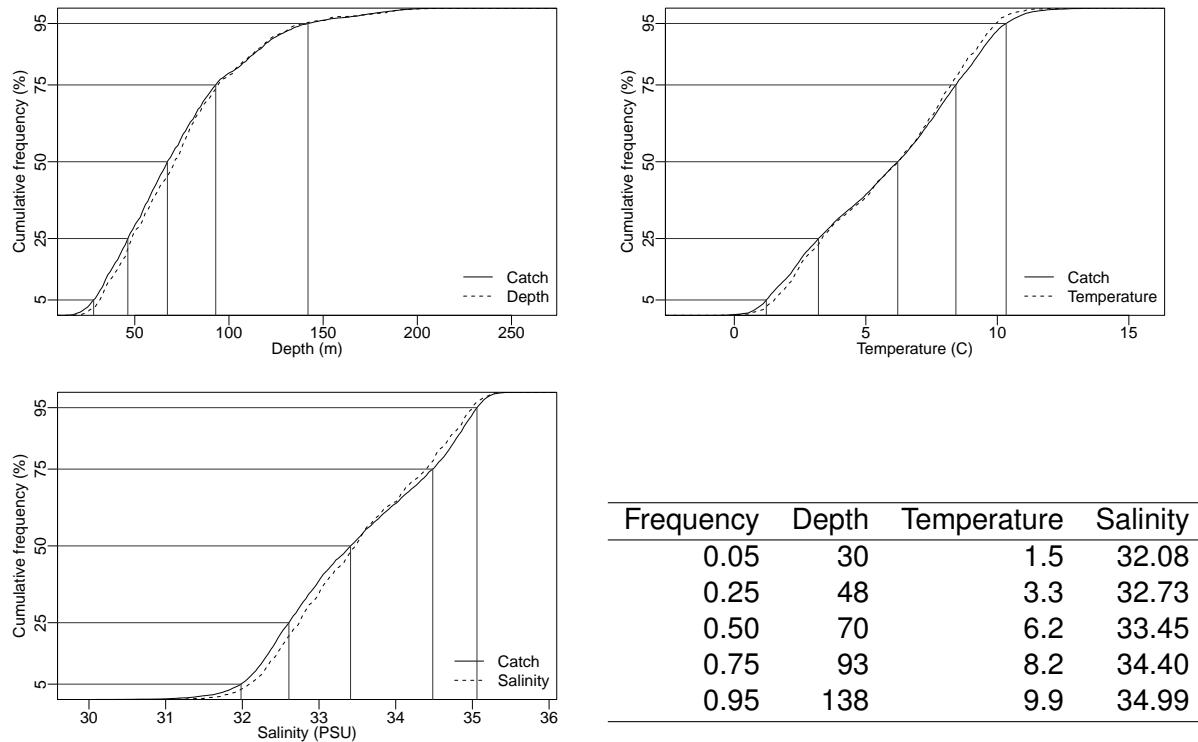


Figure 6.10E. Catch distribution by depth, temperature and salinity of Witch flounder.

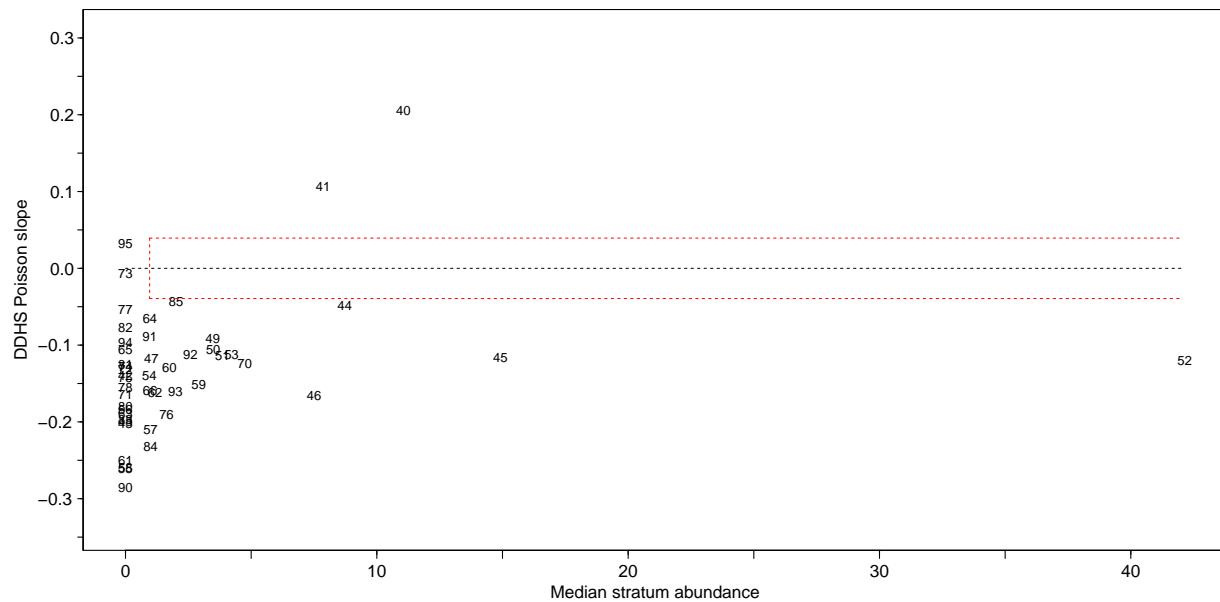


Figure 6.10F. DDHS slopes versus median stratum abundance for Witch flounder. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.11 Yellowtail flounder (Limande à queue jaune) - species code 42 (category LF)

Scientific name: [Limanda ferruginea](#)

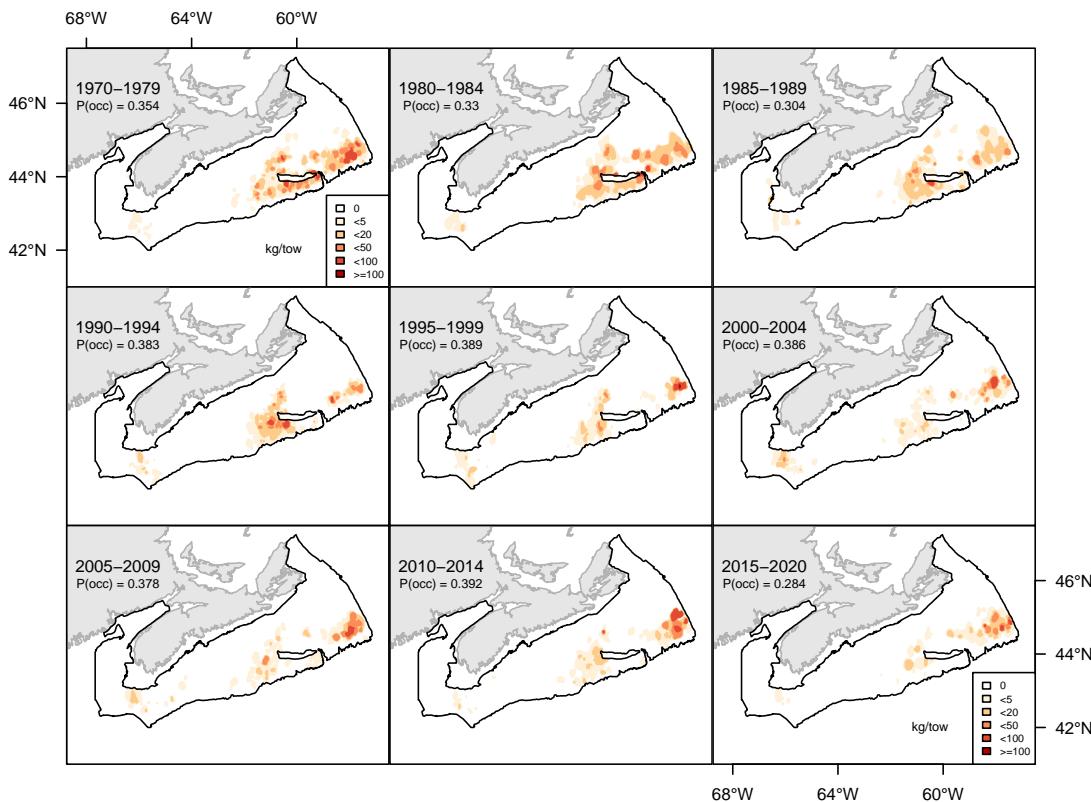


Figure 6.11A. Inverse distance weighted distribution of catch biomass (kg/tow) for Yellowtail flounder. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

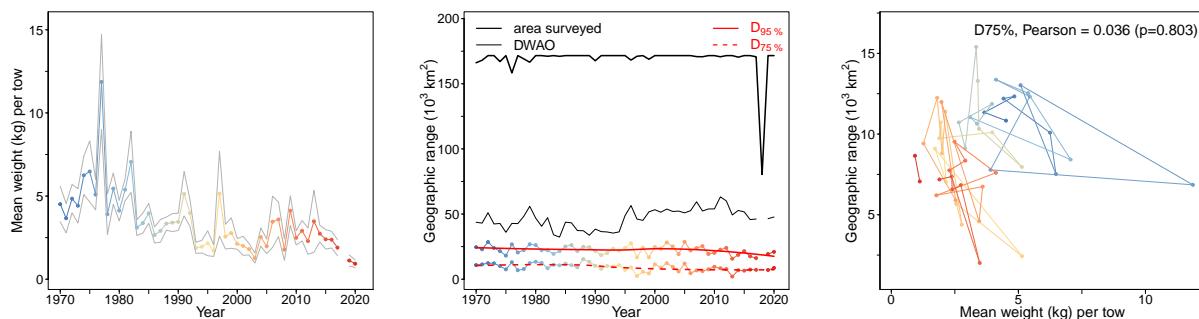


Figure 6.11B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Yellowtail flounder. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

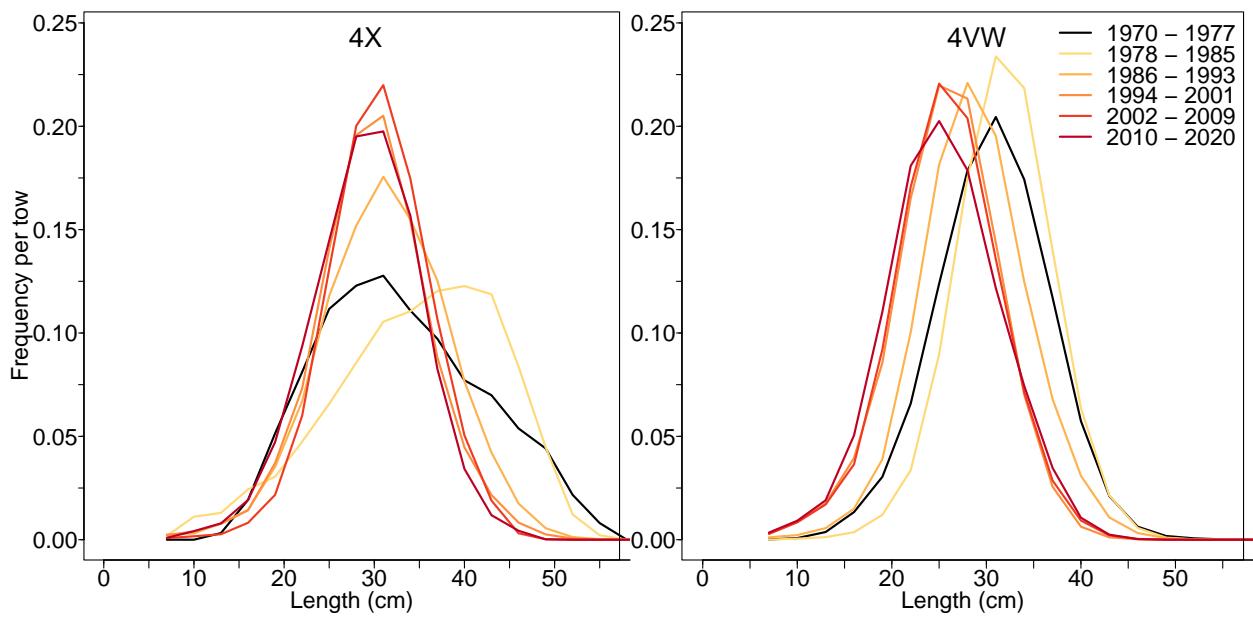


Figure 6.11C. Length frequency distribution in NAFO units 4X and 4VW for Yellowtail flounder.

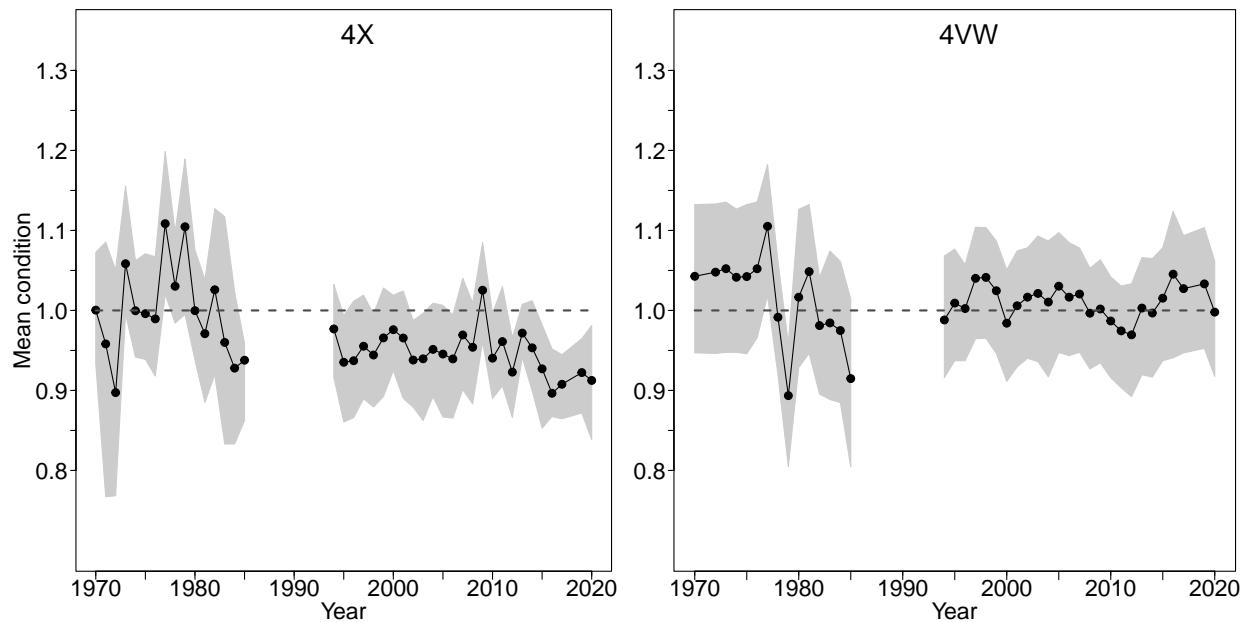


Figure 6.11D. Average fish condition in NAFO units 4X and 4VW for Yellowtail flounder.

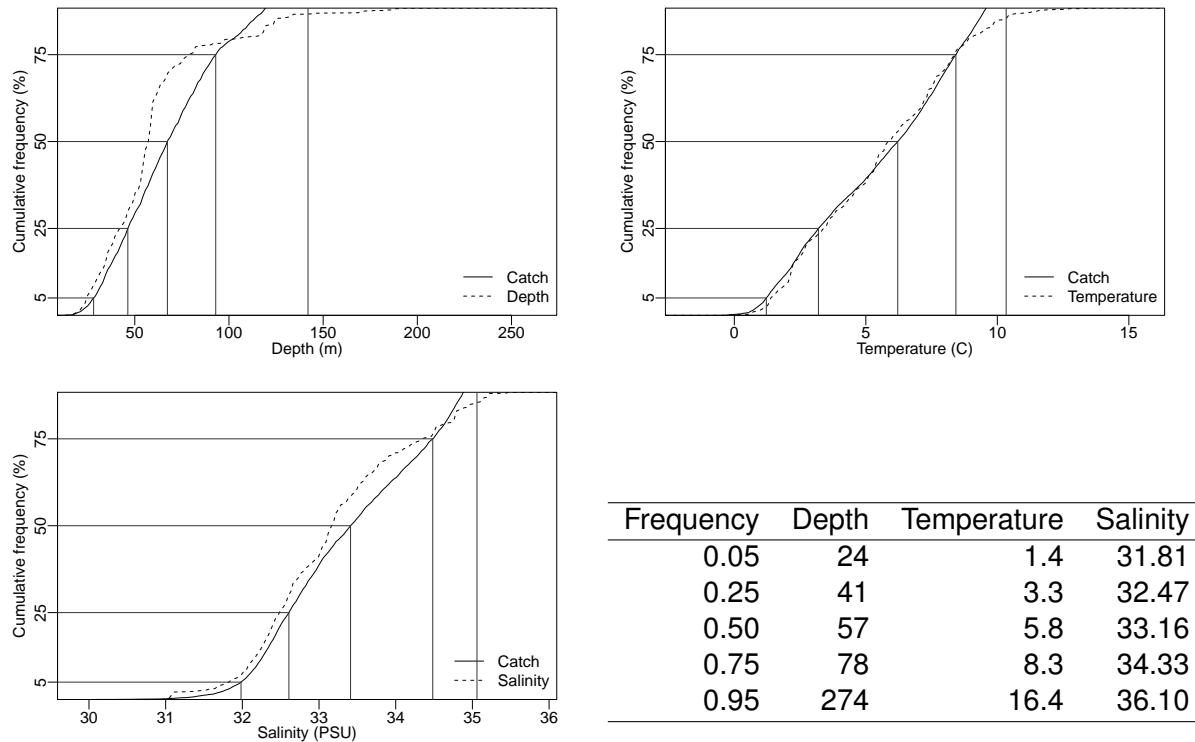


Figure 6.11E. Catch distribution by depth, temperature and salinity of Yellowtail flounder.

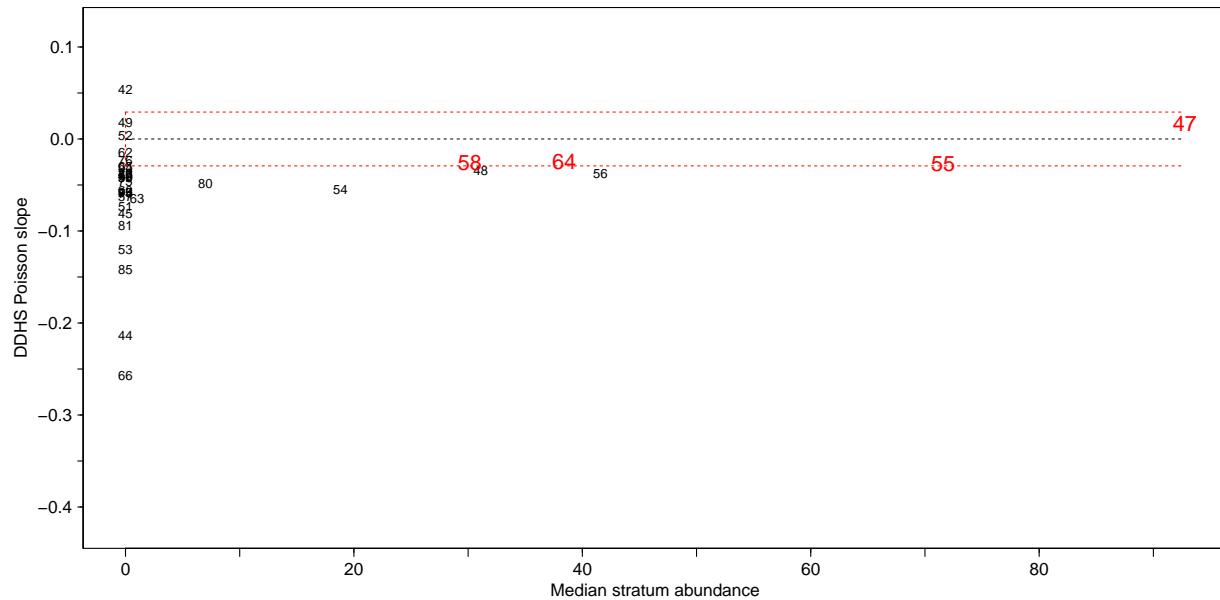


Figure 6.11F. DDHS slopes versus median stratum abundance for Yellowtail flounder. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.12 Winter flounder (Limande-plie rouge) - species code 43 (category LF)

Scientific name: [Pseudopleuronectes americanus](#)

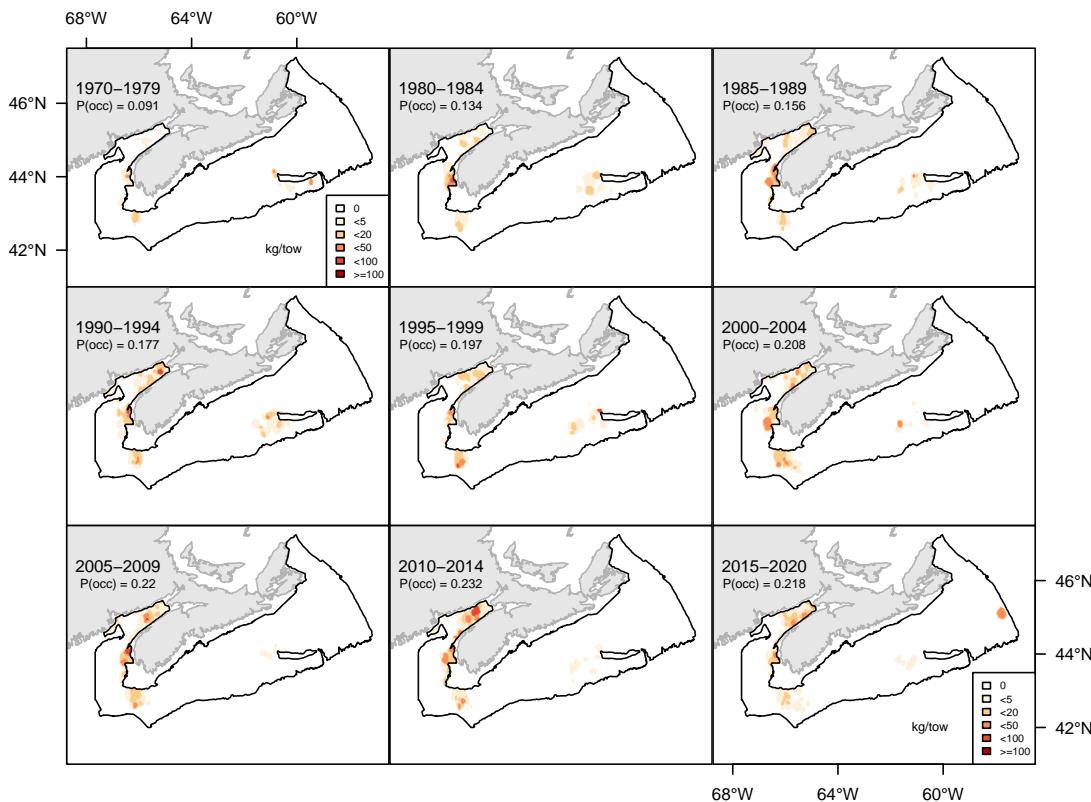


Figure 6.12A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter flounder. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

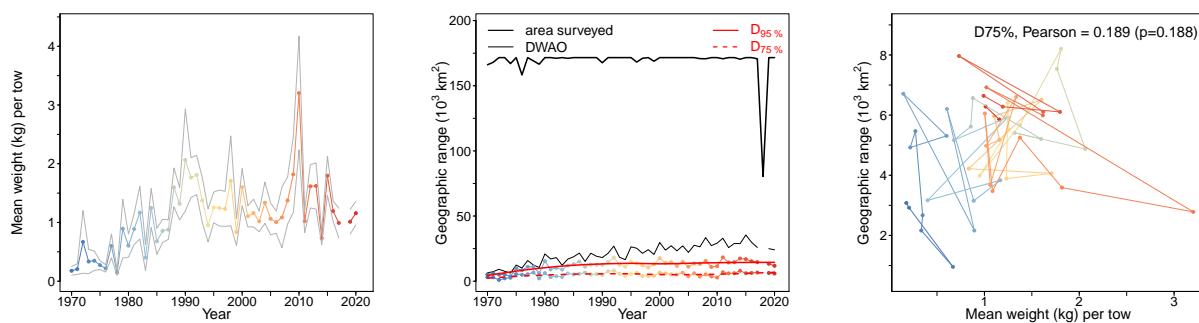


Figure 6.12B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter flounder. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

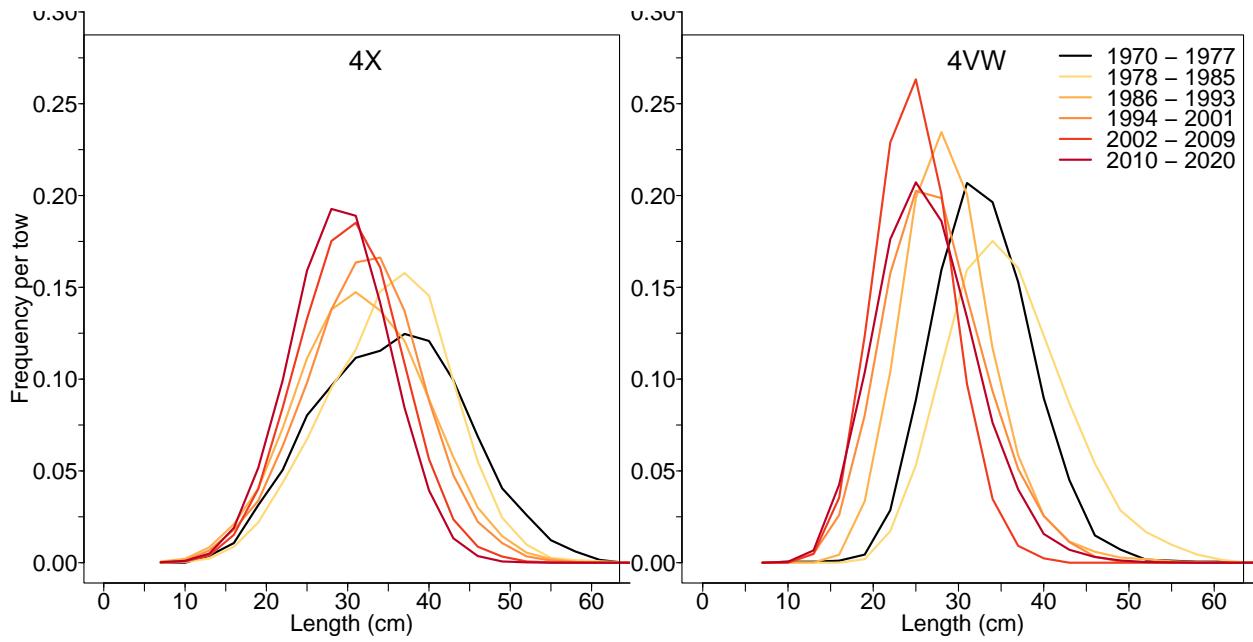


Figure 6.12C. Length frequency distribution in NAFO units 4X and 4VW for Winter flounder.

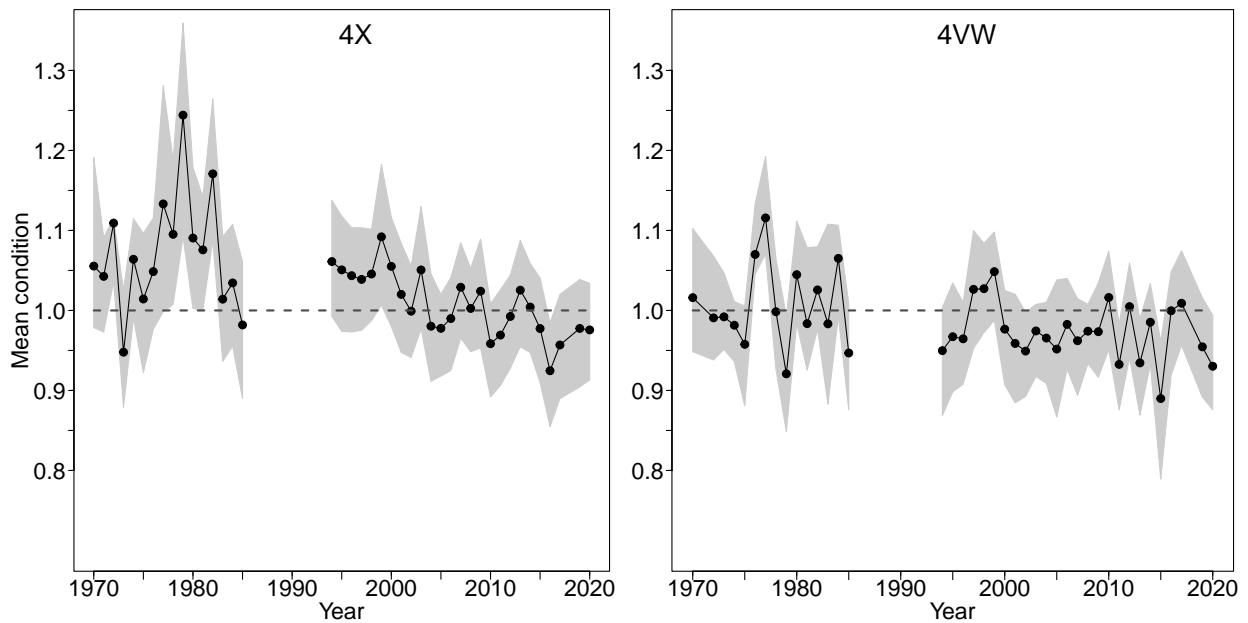


Figure 6.12D. Average fish condition in NAFO units 4X and 4VW for Winter flounder.

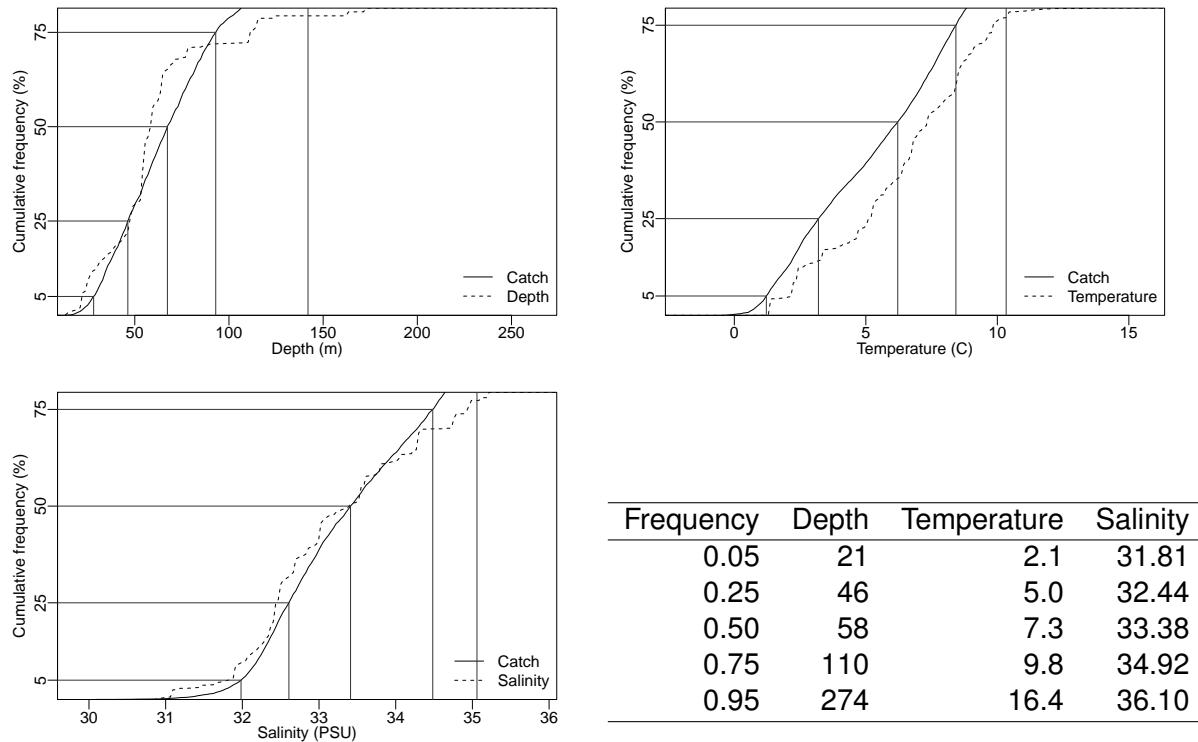


Figure 6.12E. Catch distribution by depth, temperature and salinity of Winter flounder.

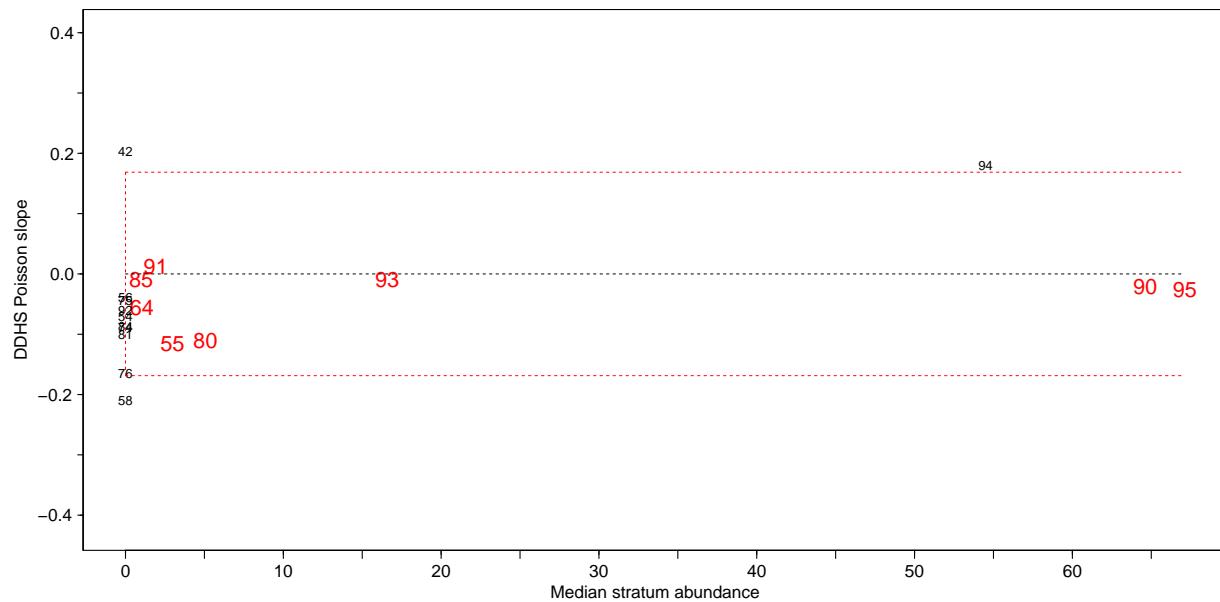


Figure 6.12F. DDHS slopes versus median stratum abundance for Winter flounder. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.13 Atlantic redfishes (Sébastes de l'Atlantique) - species code 23 (category LF)

Scientific name: [Sebastes](#)

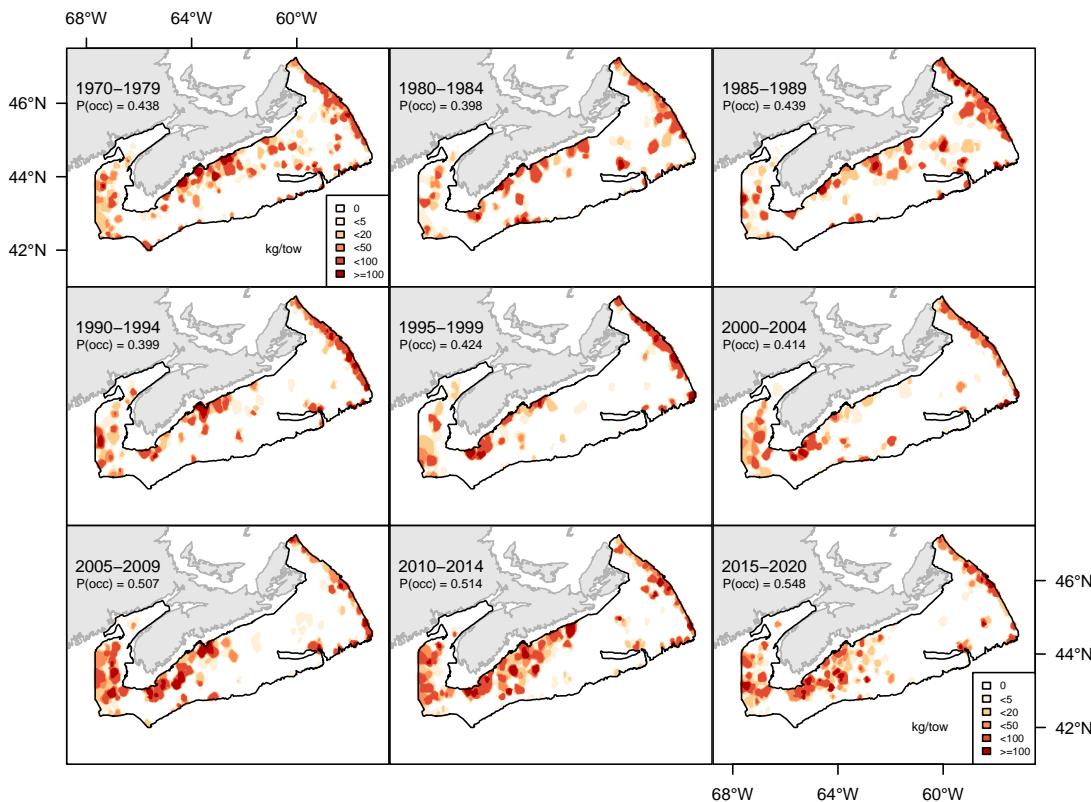


Figure 6.13A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic redfishes. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

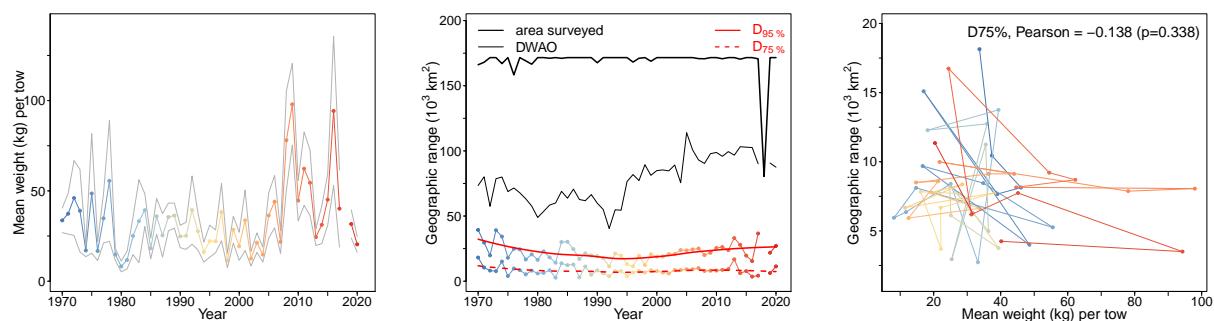


Figure 6.13B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic redfishes. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

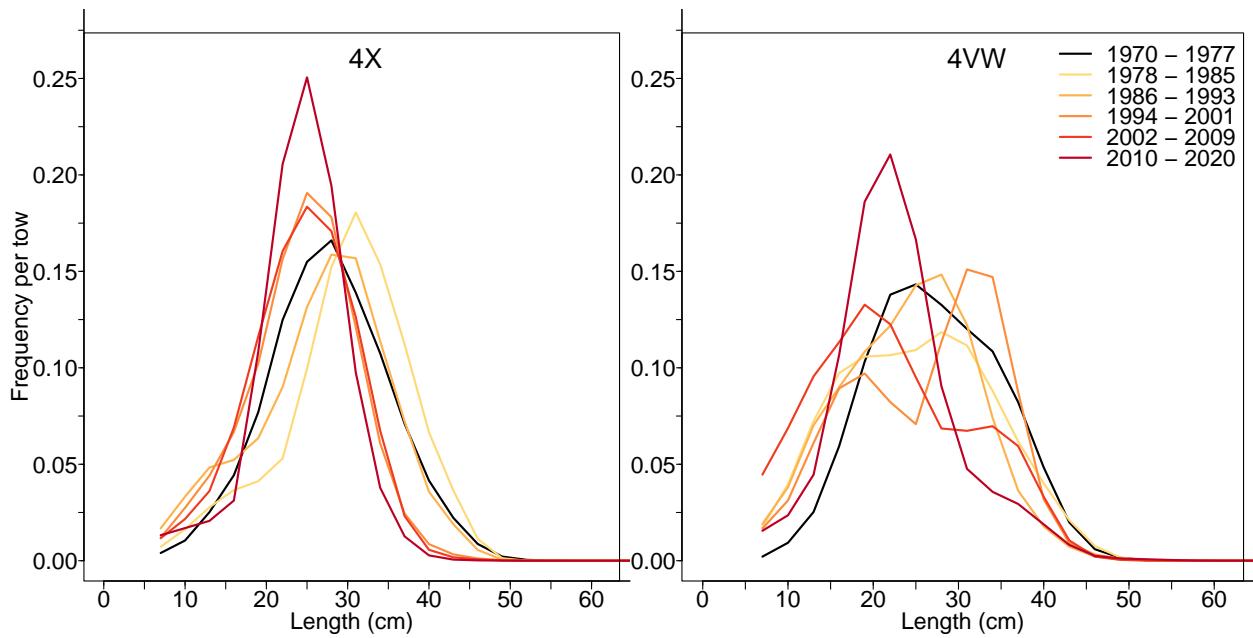


Figure 6.13C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic redfishes.

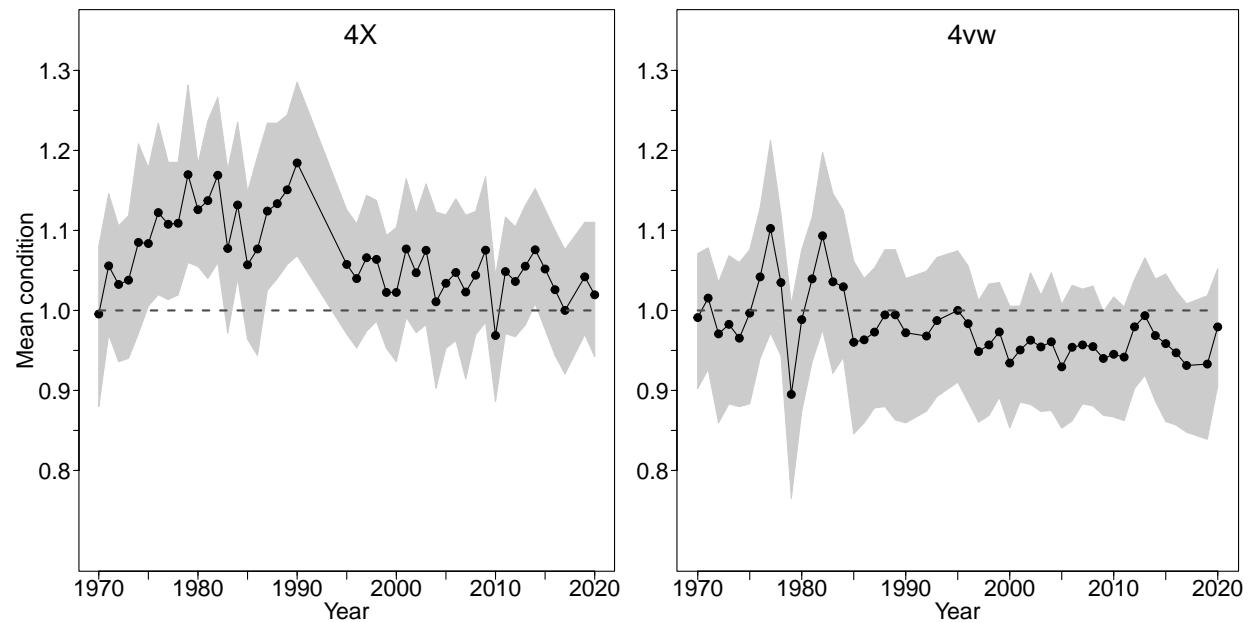


Figure 6.13D. Average fish condition in NAFO units 4X and 4VW for Atlantic redfishes.

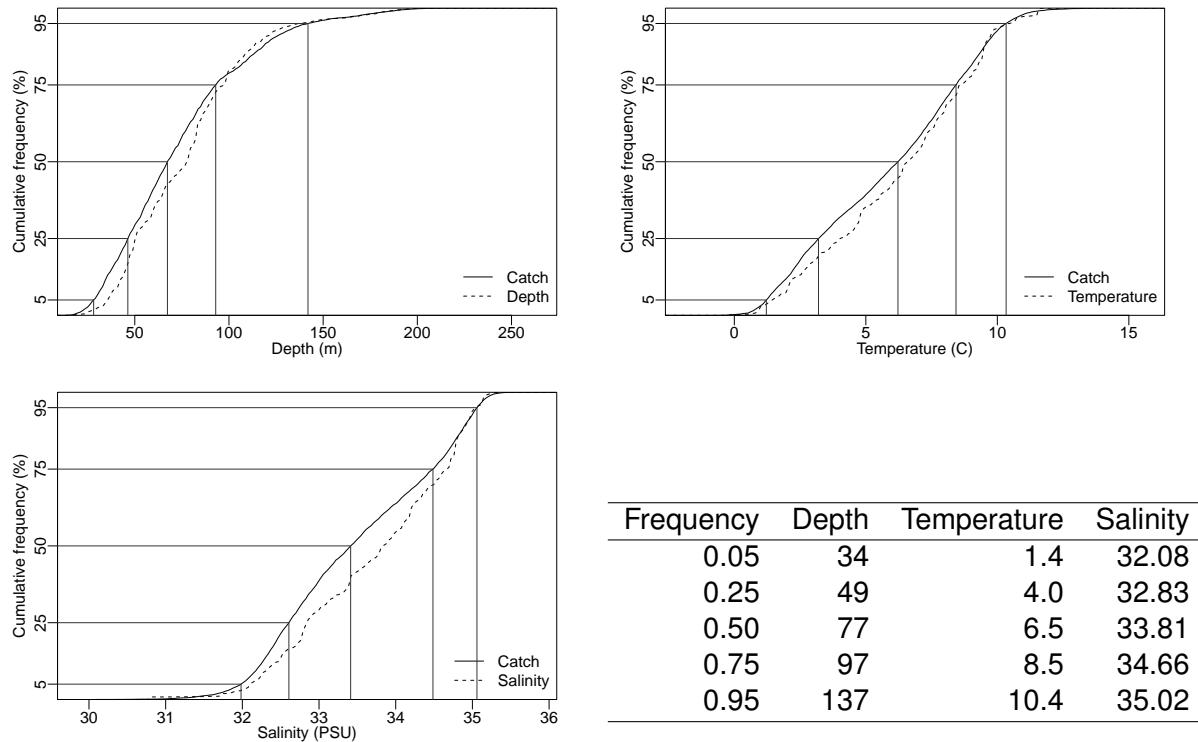


Figure 6.13E. Catch distribution by depth, temperature and salinity of Atlantic redfishes.

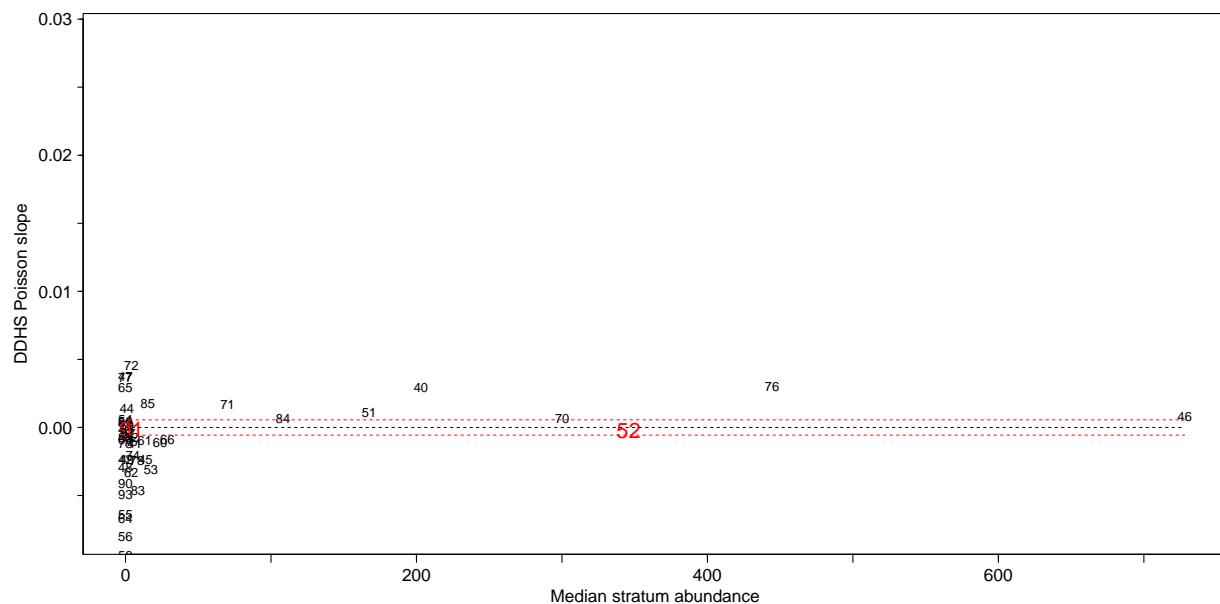


Figure 6.13F. DDHS slopes versus median stratum abundance for Atlantic redfishes. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.14 Atlantic wolffish (Loup atlantique) - species code 50 (category LF)

Scientific name: [Anarhichas lupus](#)

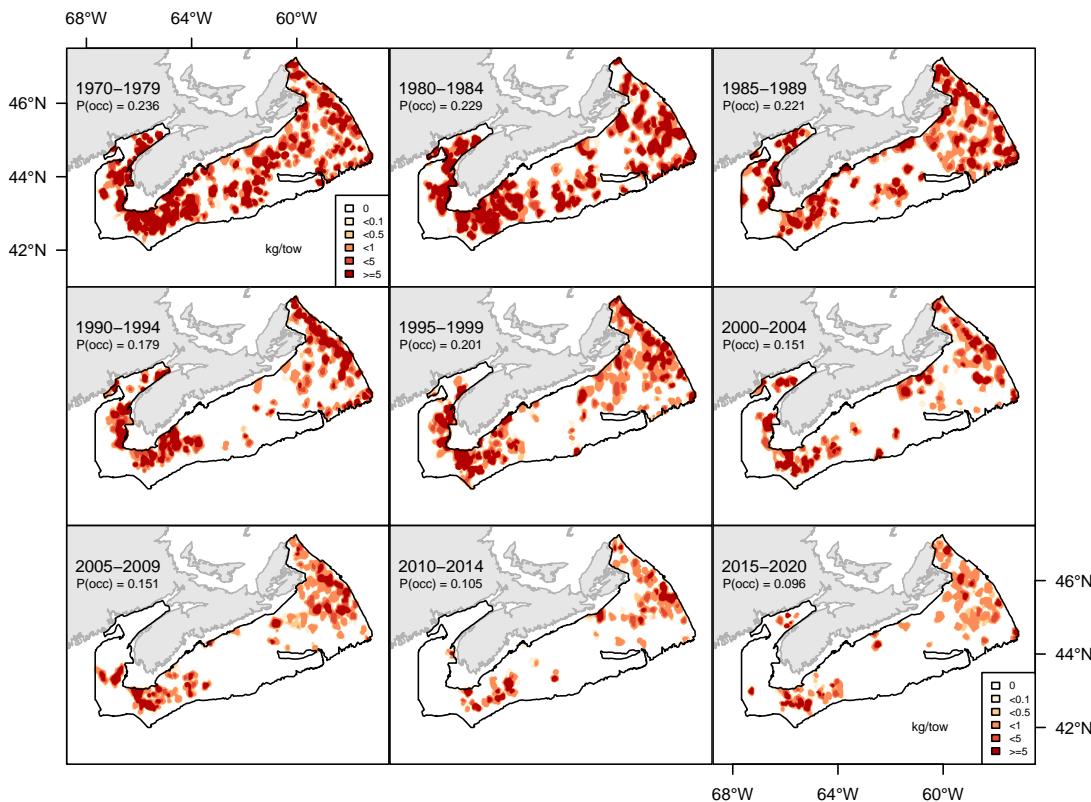


Figure 6.14A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic wolffish. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

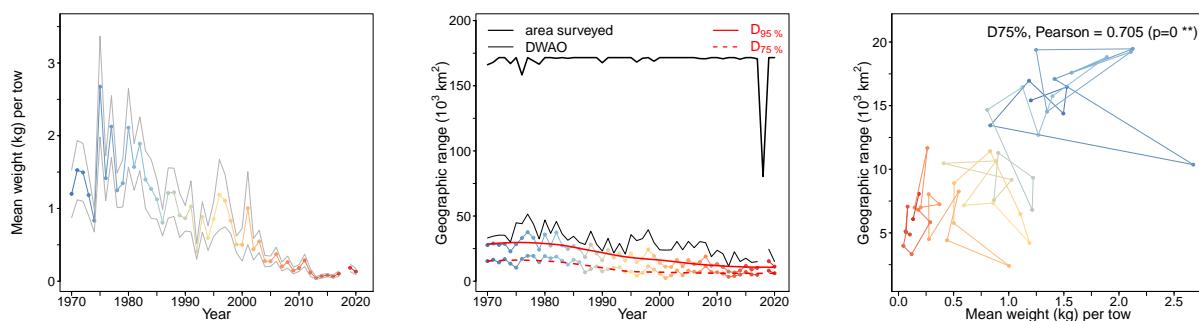


Figure 6.14B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic wolffish. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

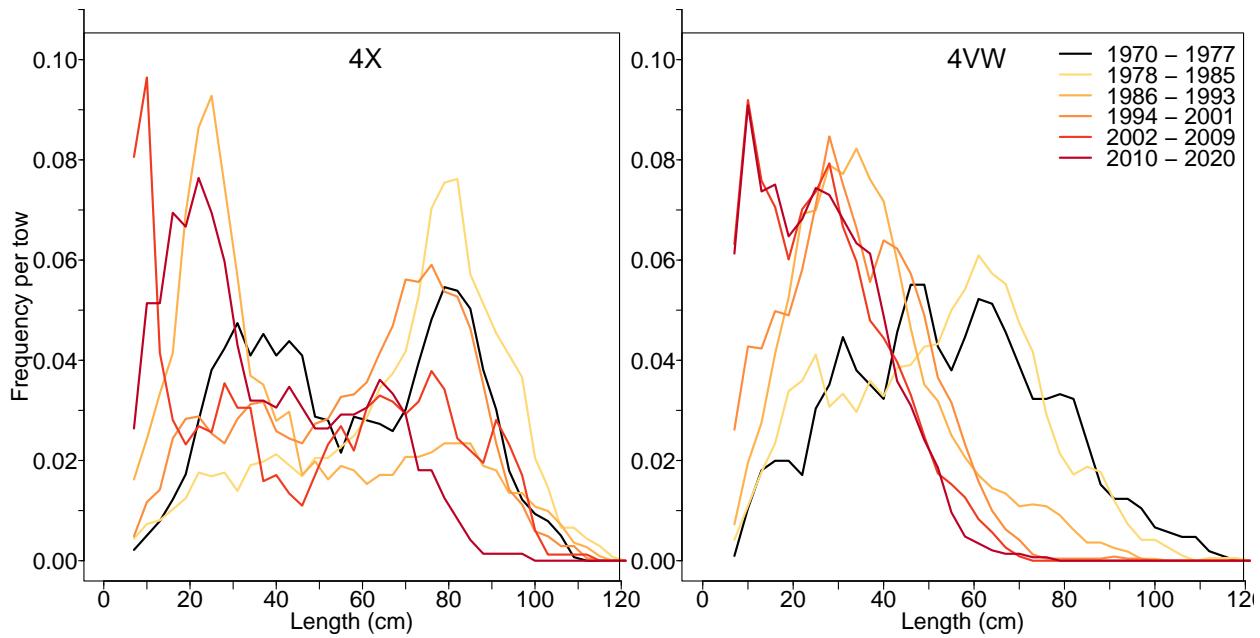


Figure 6.14C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic wolffish.

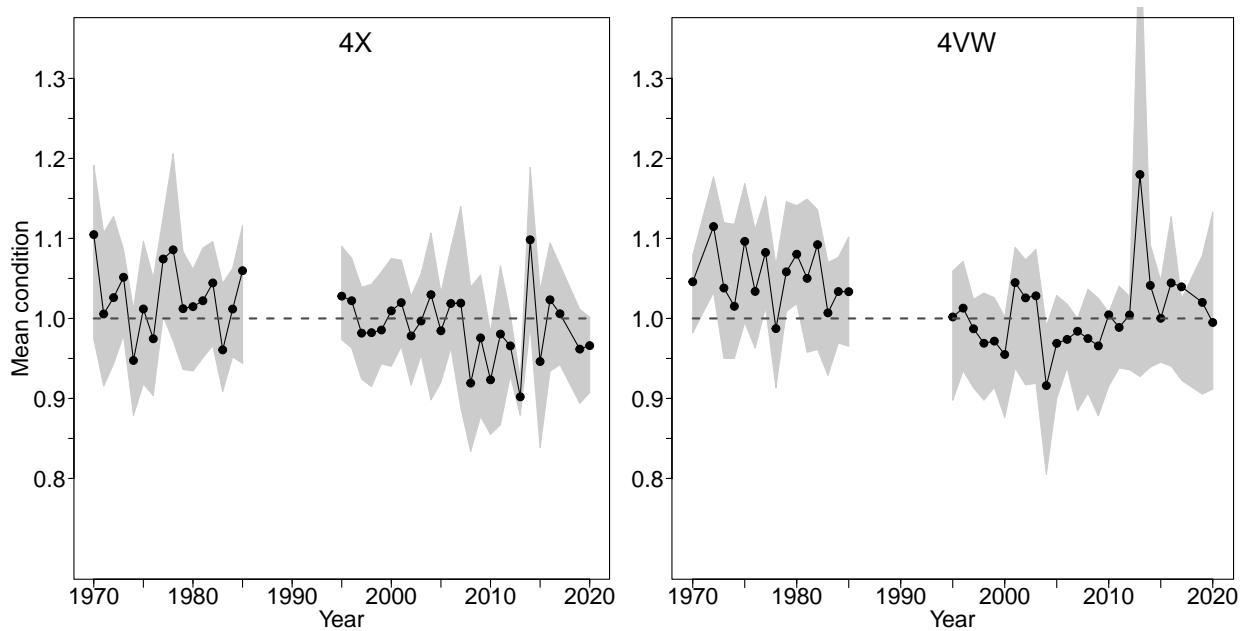


Figure 6.14D. Average fish condition in NAFO units 4X and 4VW for Atlantic wolffish.

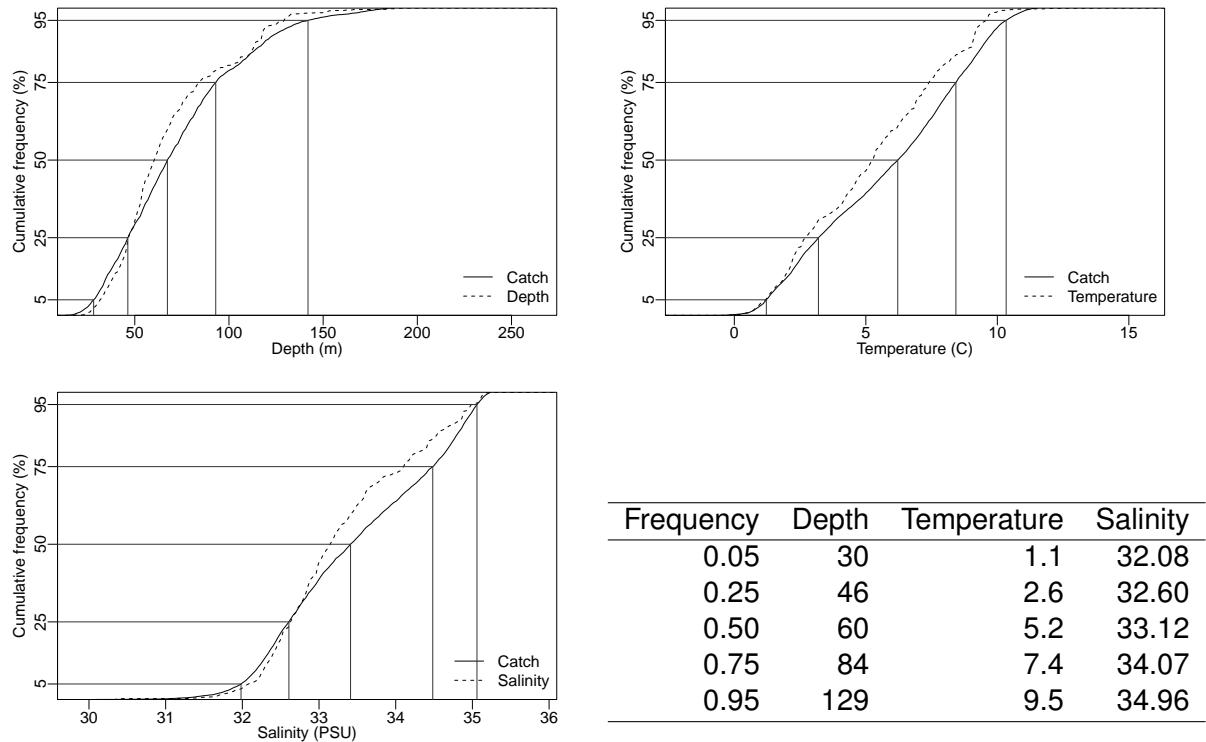


Figure 6.14E. Catch distribution by depth, temperature and salinity of Atlantic wolffish.

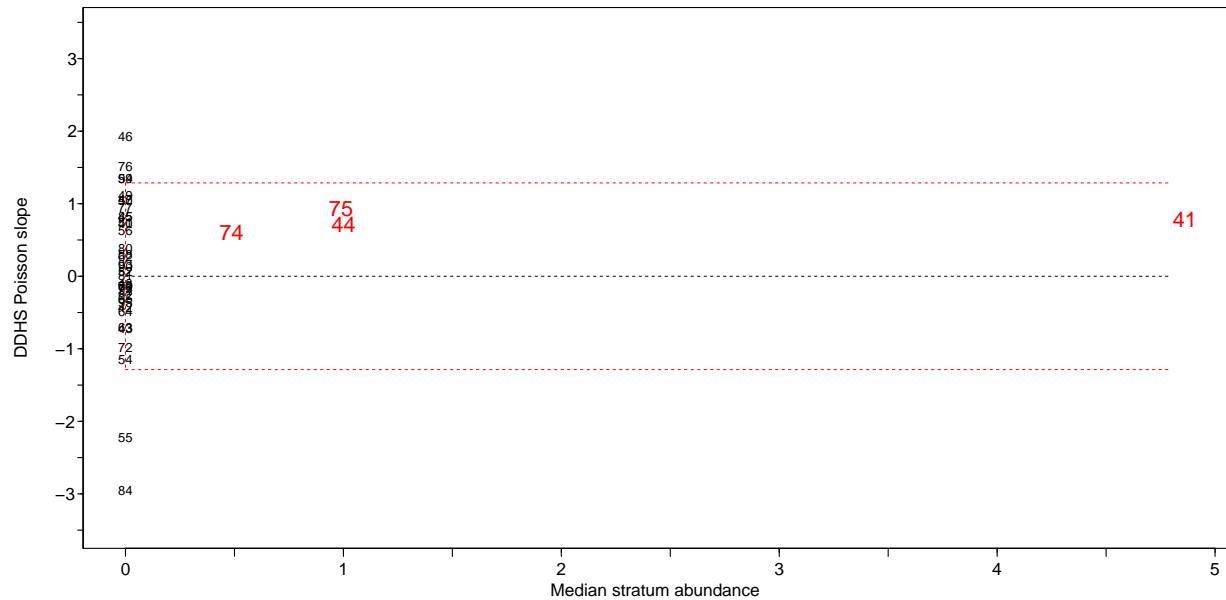


Figure 6.14F. DDHS slopes versus median stratum abundance for Atlantic wolffish. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.15 Longhorn sculpin (Chabosseau à 18 épines) - species code 300 (category LF)

Scientific name: [Myoxocephalus octodecemspinosis](#)

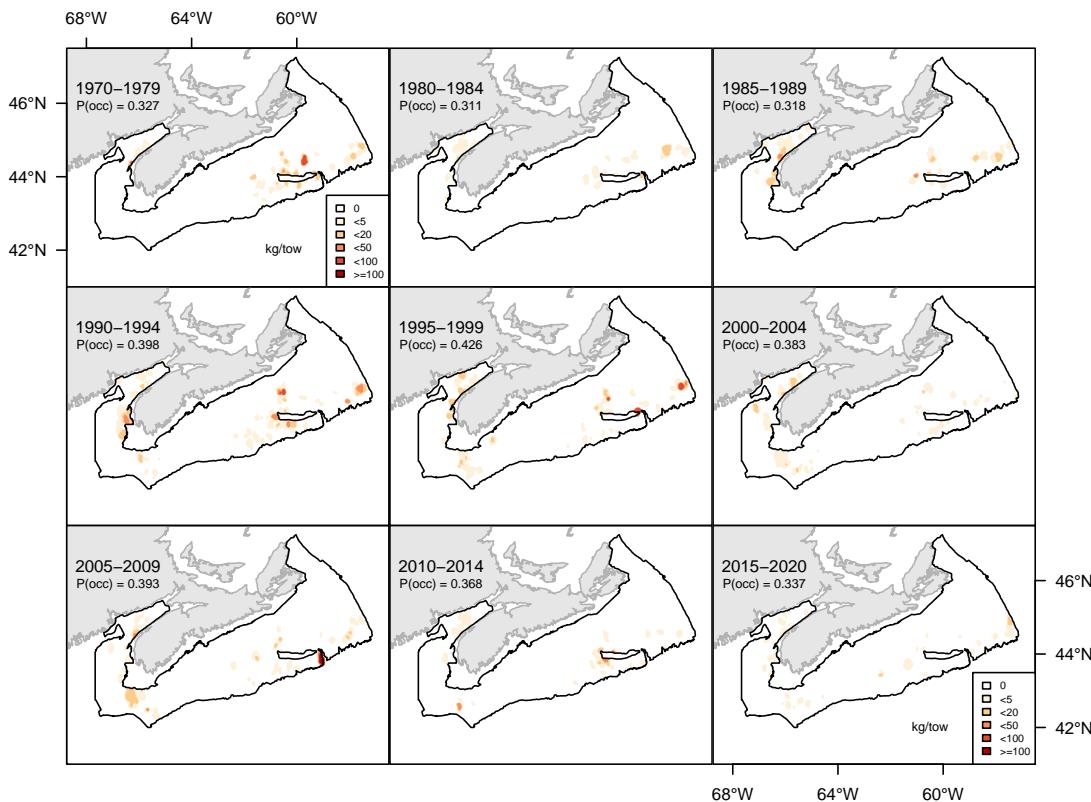


Figure 6.15A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longhorn sculpin. $P(occ)$ is the proportion of tows with catch records for each 5-year period.

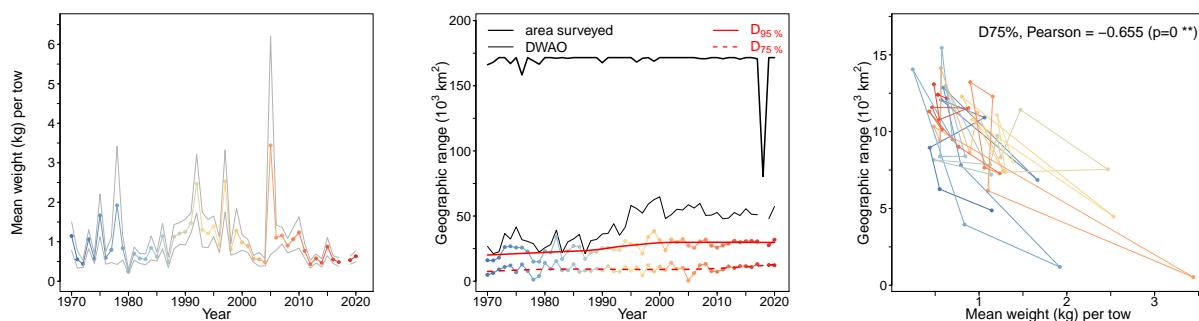


Figure 6.15B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longhorn sculpin. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

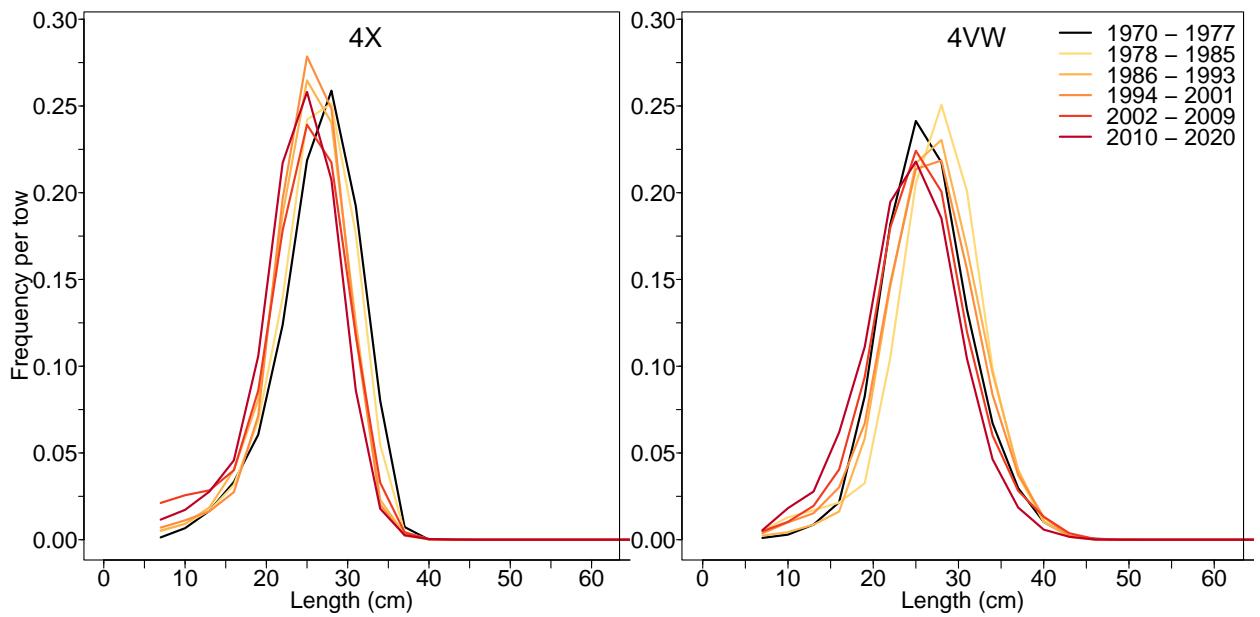


Figure 6.15C. Length frequency distribution in NAFO units 4X and 4VW for Longhorn sculpin.

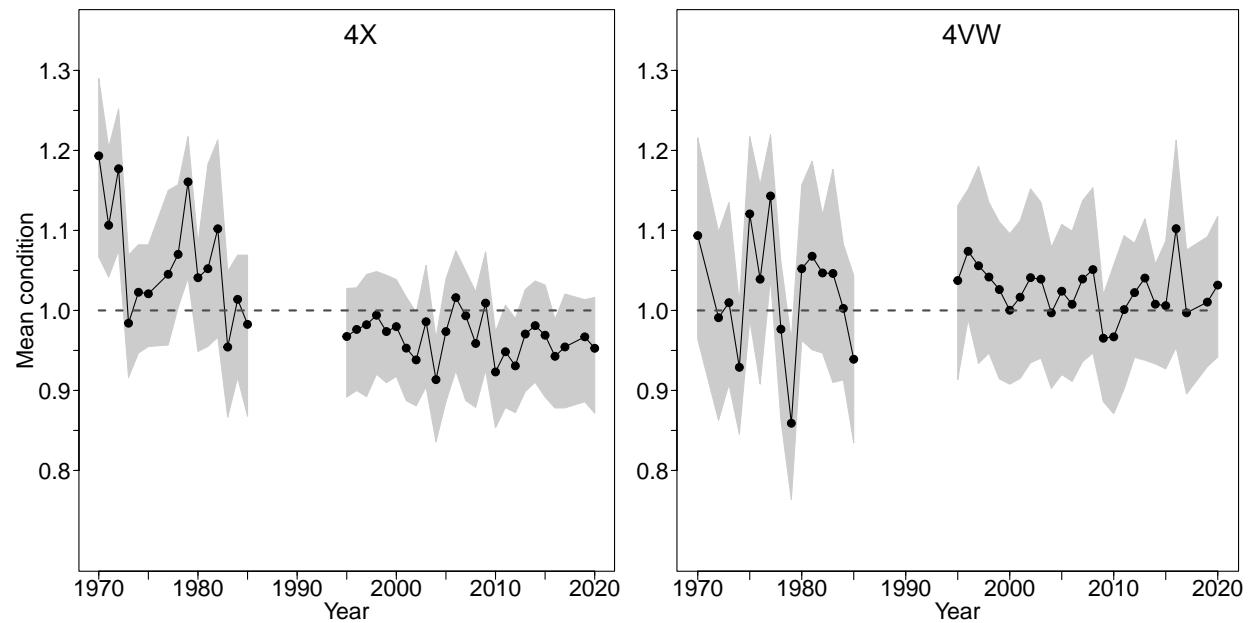


Figure 6.15D. Average fish condition in NAFO units 4X and 4VW for Longhorn sculpin.

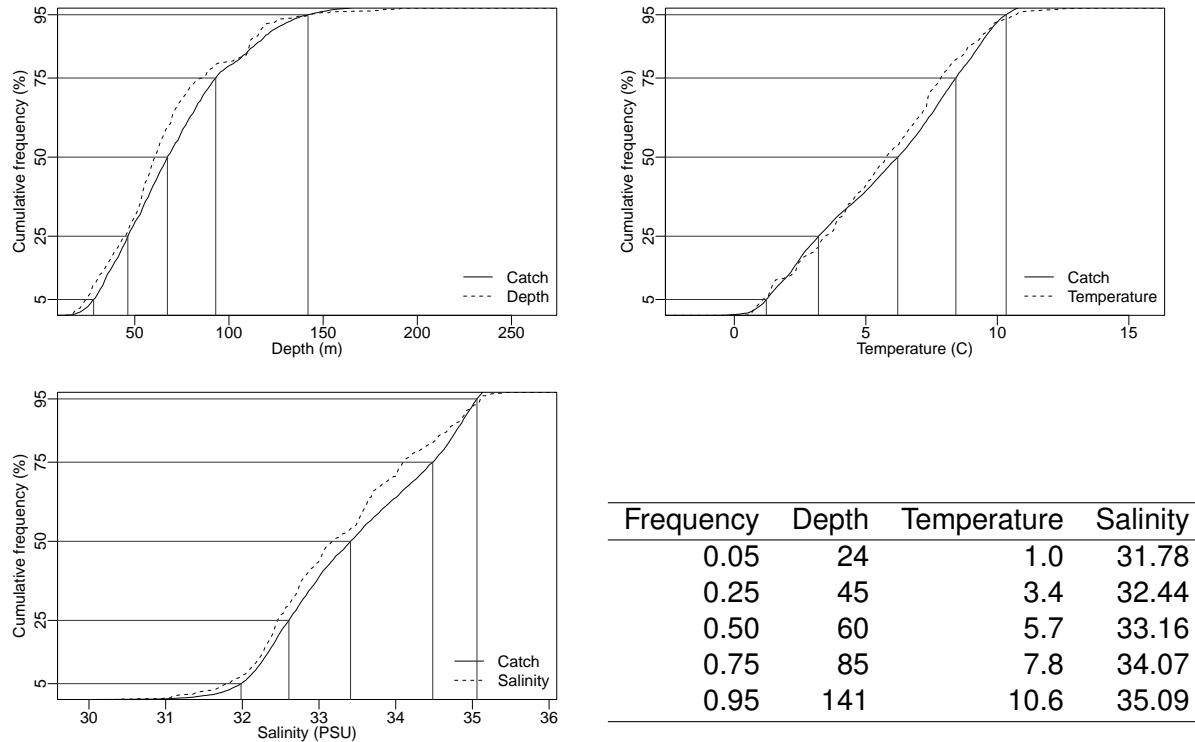


Figure 6.15E. Catch distribution by depth, temperature and salinity of Longhorn sculpin.

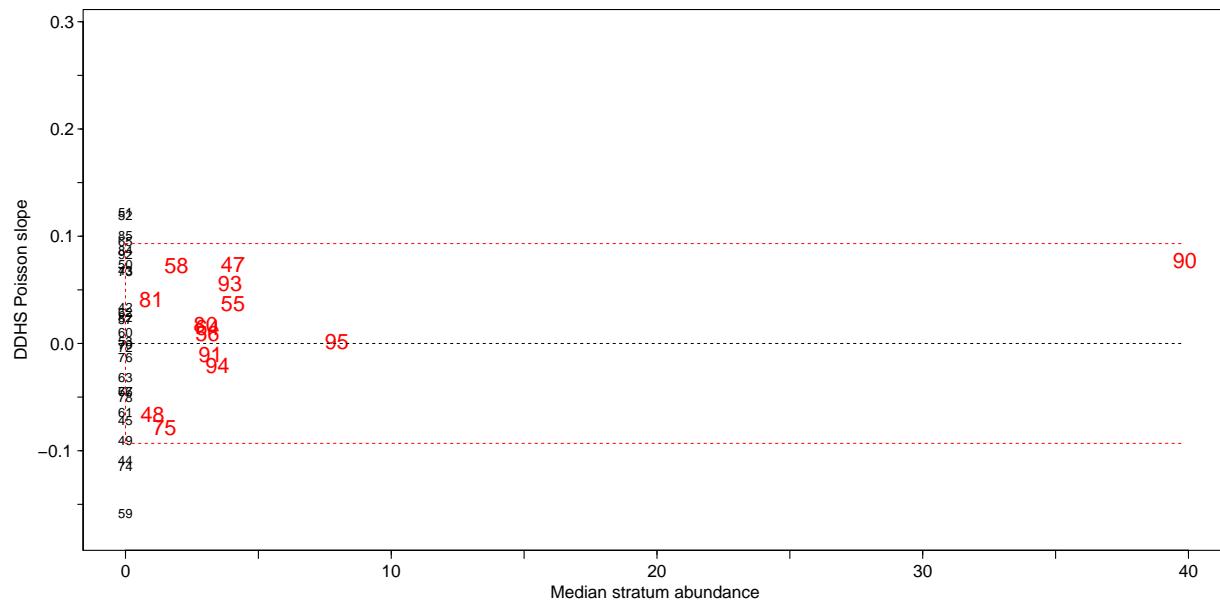


Figure 6.15F. DDHS slopes versus median stratum abundance for Longhorn sculpin. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.16 Atlantic herring (Hareng de l'Atlantique) - species code 60 (category LF)

Scientific name: [Clupea harengus](#)

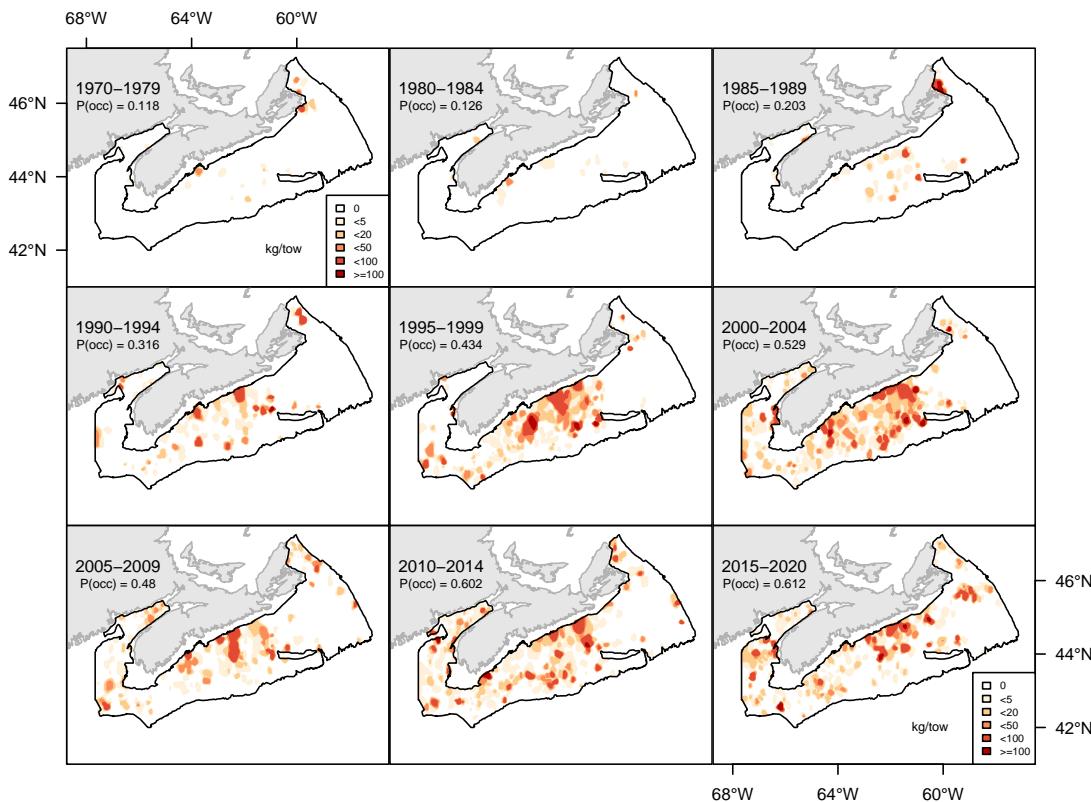


Figure 6.16A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic herring. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

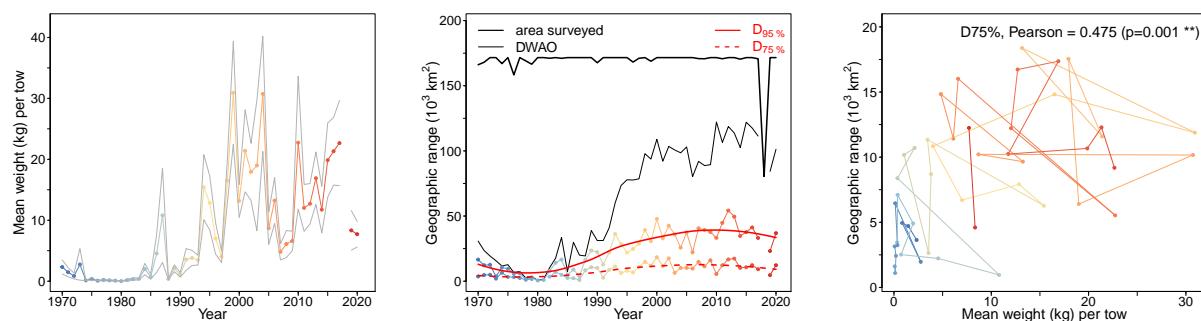


Figure 6.16B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic herring. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

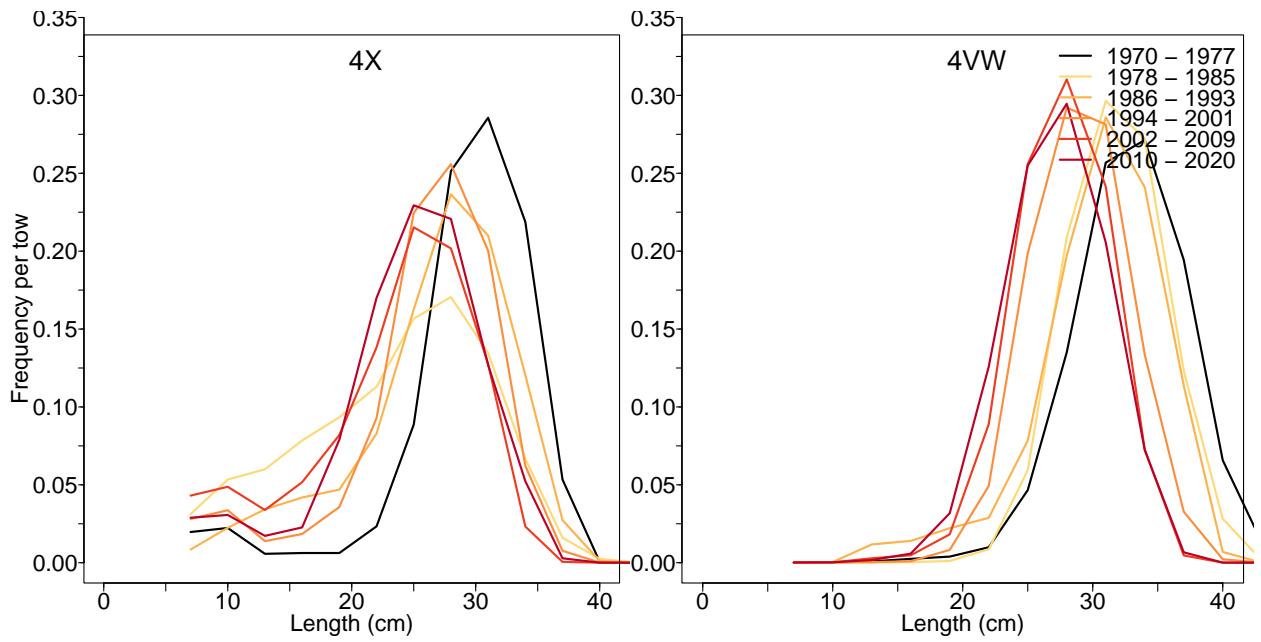


Figure 6.16C. Length frequency distribution in NAFO units 4X and 4VW for Atlantic herring.

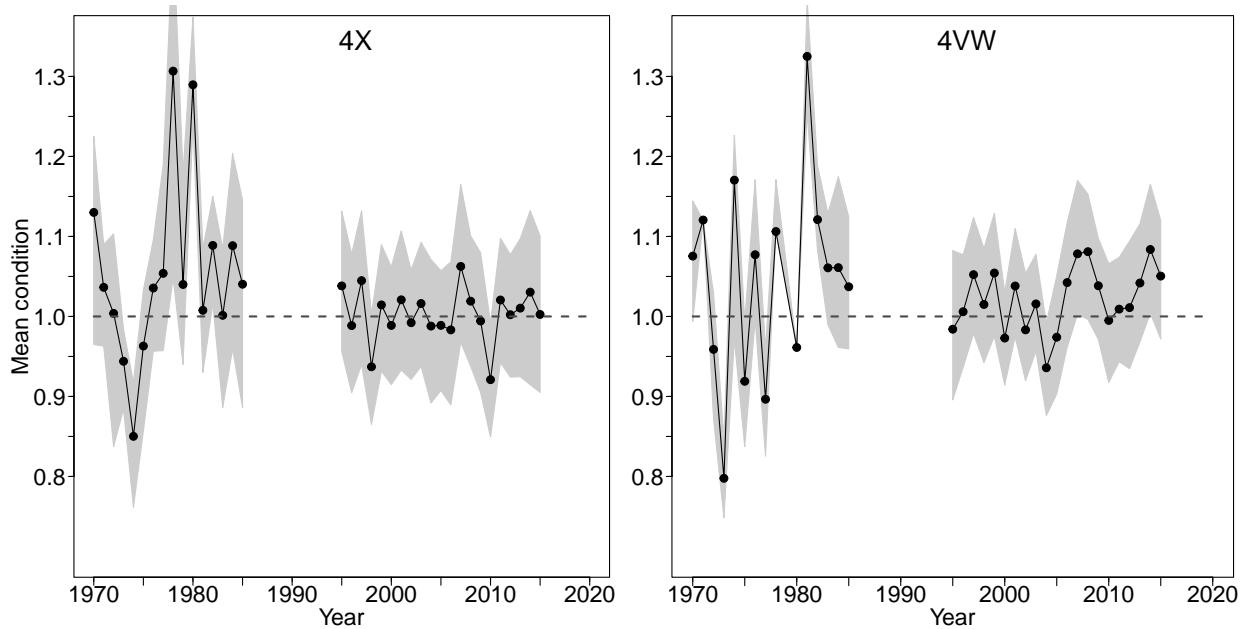


Figure 6.16D. Average fish condition in NAFO units 4X and 4VW for Atlantic herring.

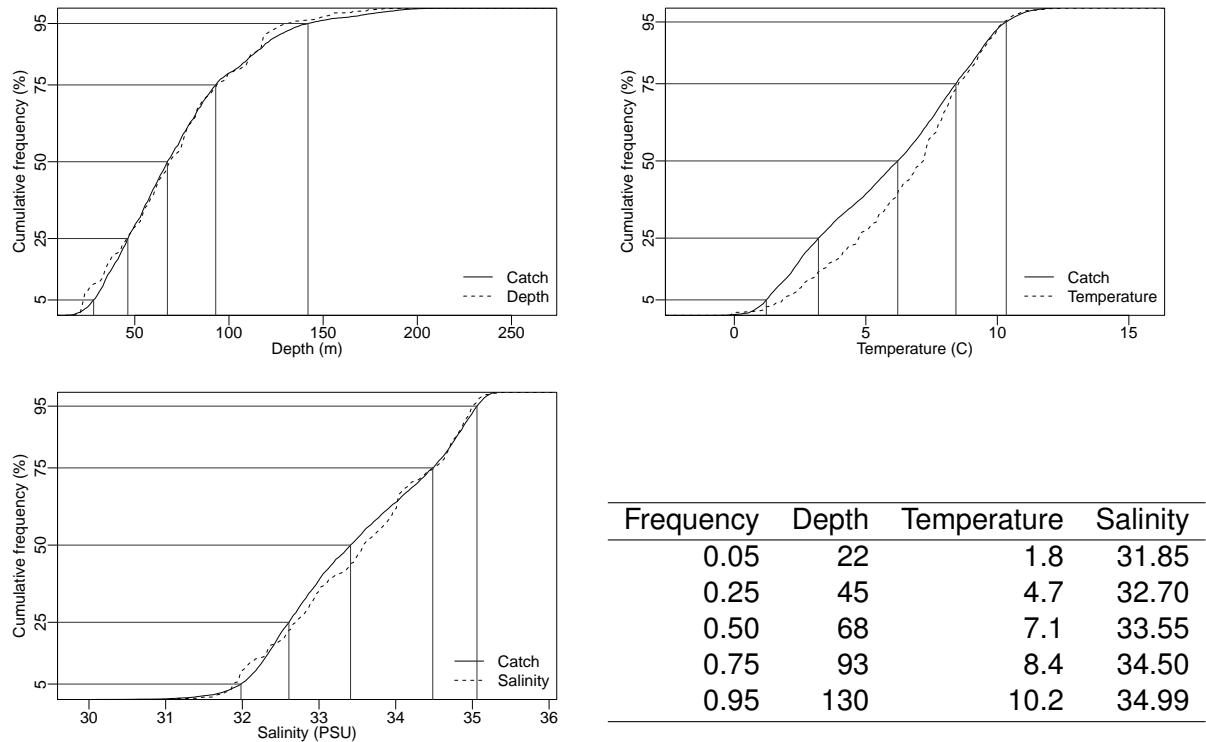


Figure 6.16E. Catch distribution by depth, temperature and salinity of Atlantic herring.

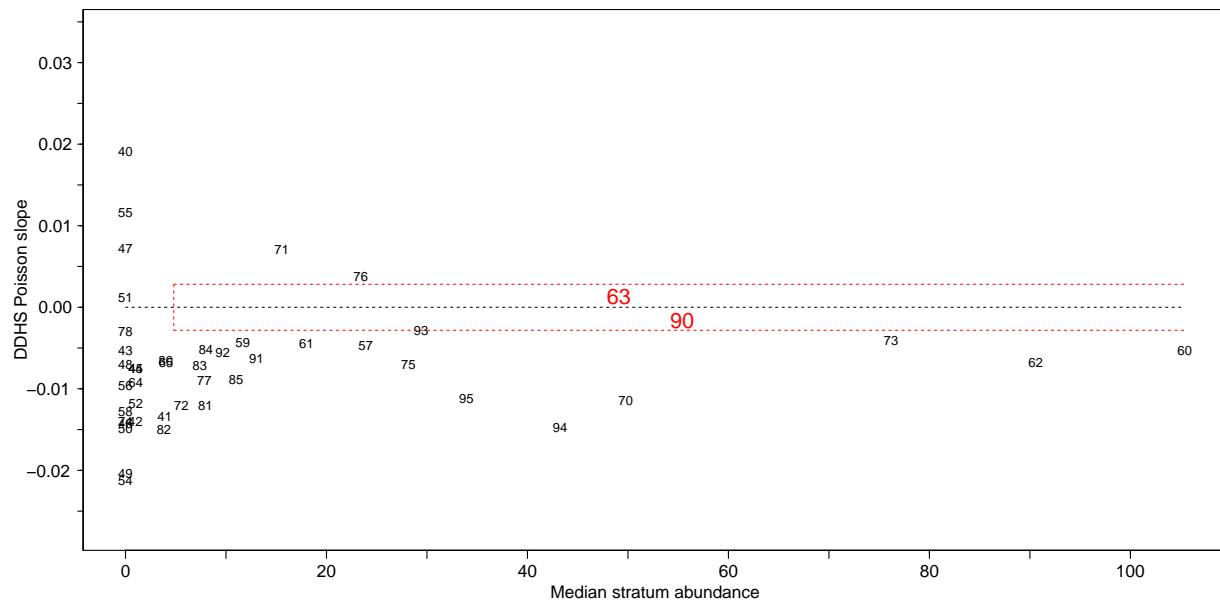


Figure 6.16F. DDHS slopes versus median stratum abundance for Atlantic herring. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.17 Monkfish (Baudroie d'Amérique) - species code 400 (category LF)

Scientific name: [Lophius americanus](#)

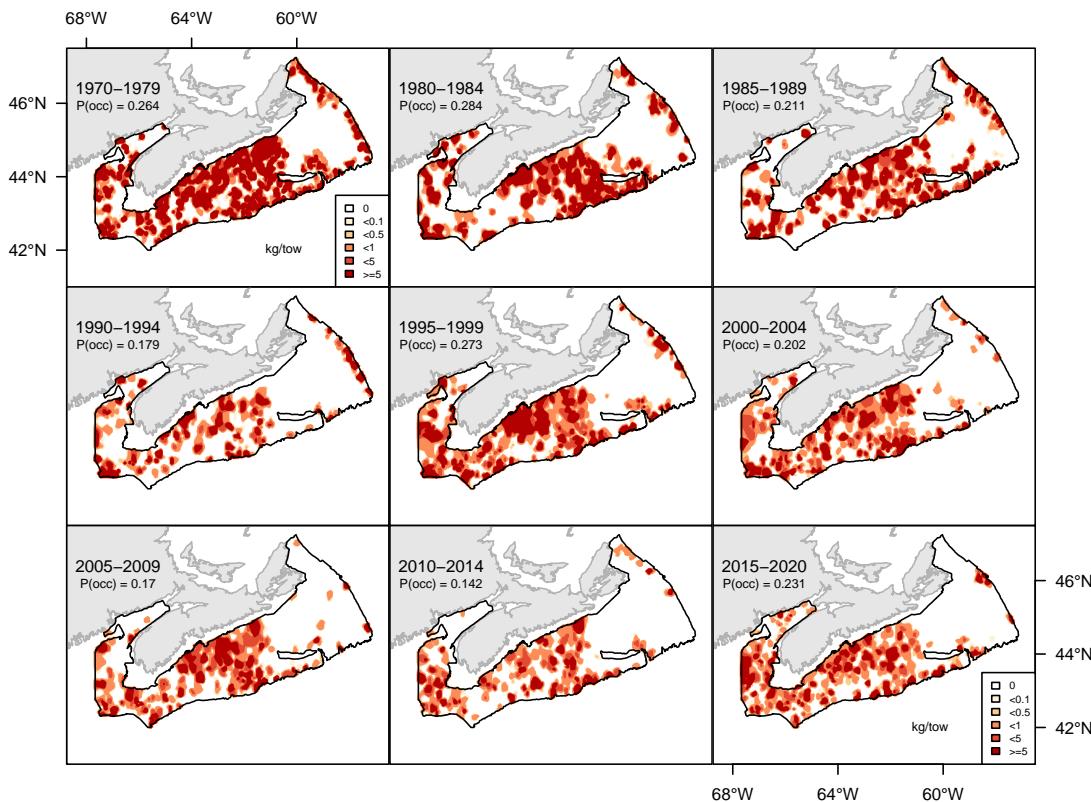


Figure 6.17A. Inverse distance weighted distribution of catch biomass (kg/tow) for Monkfish. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

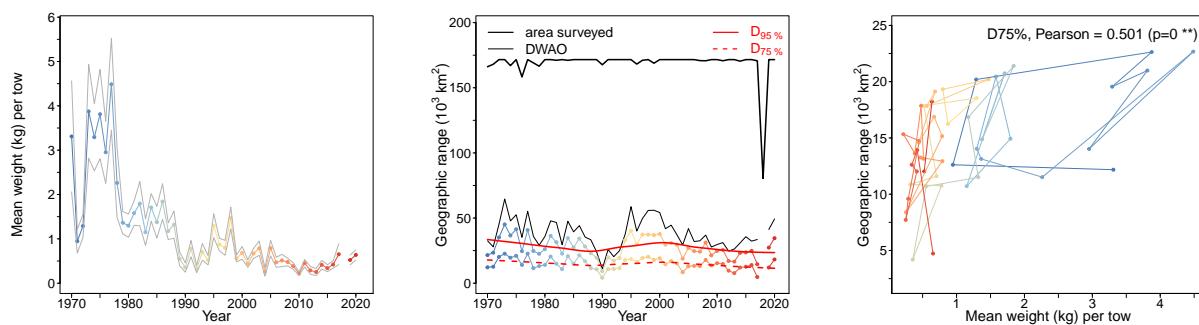


Figure 6.17B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Monkfish. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

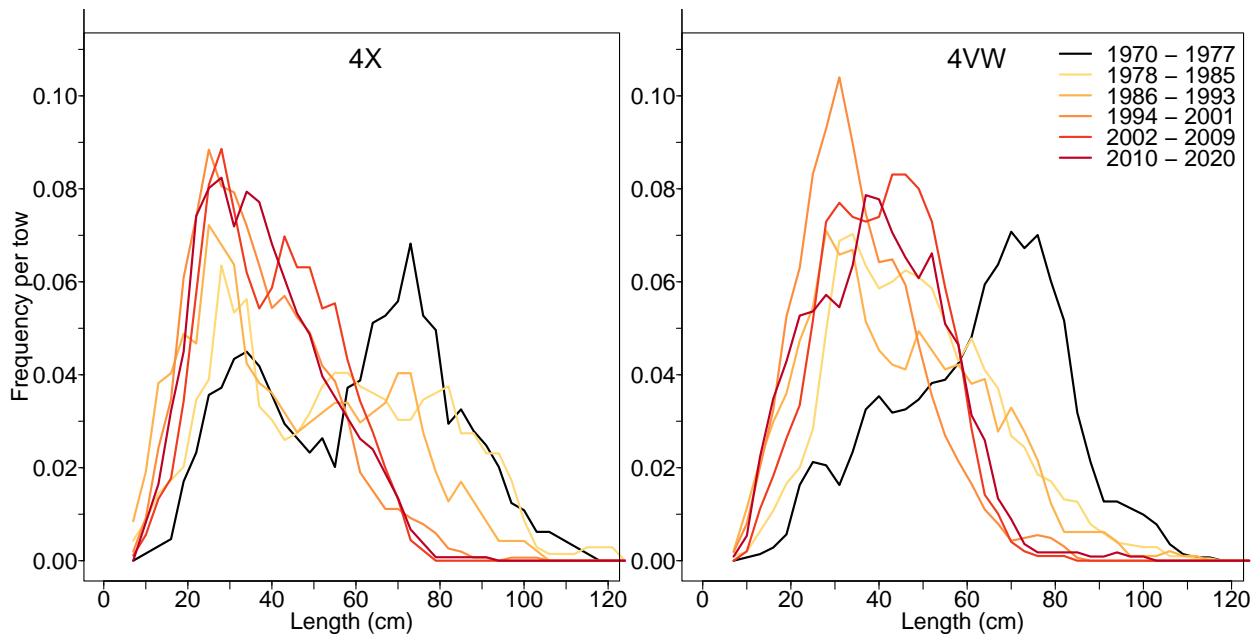


Figure 6.17C. Length frequency distribution in NAFO units 4X and 4VW for Monkfish.

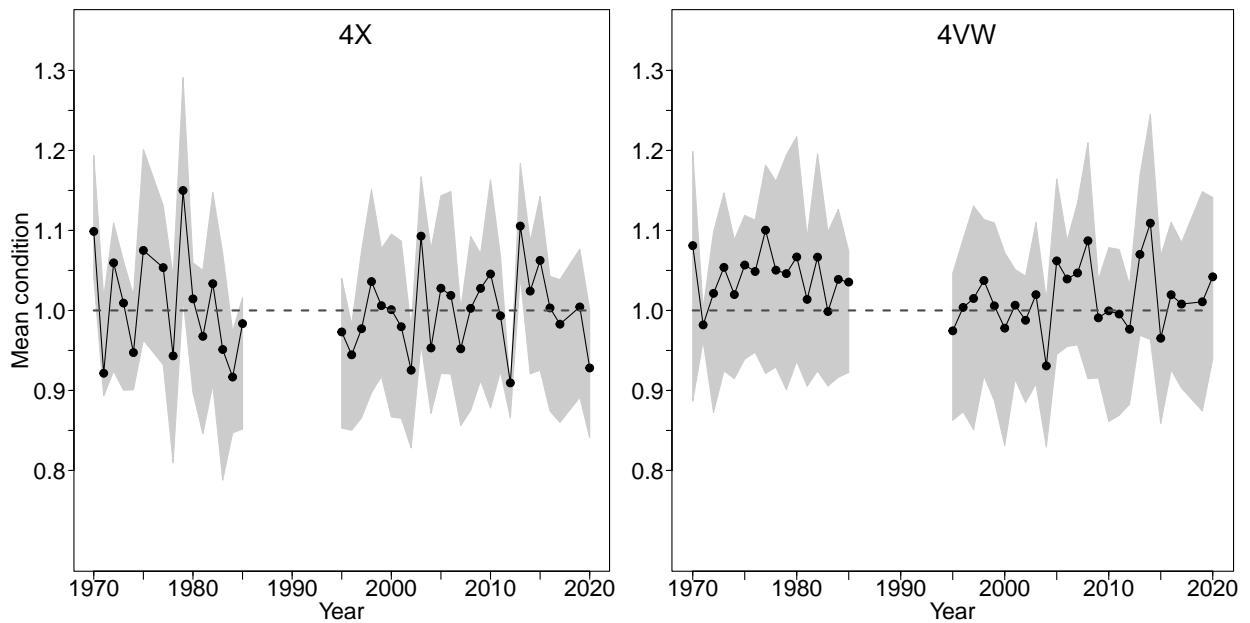


Figure 6.17D. Average fish condition in NAFO units 4X and 4VW for Monkfish.

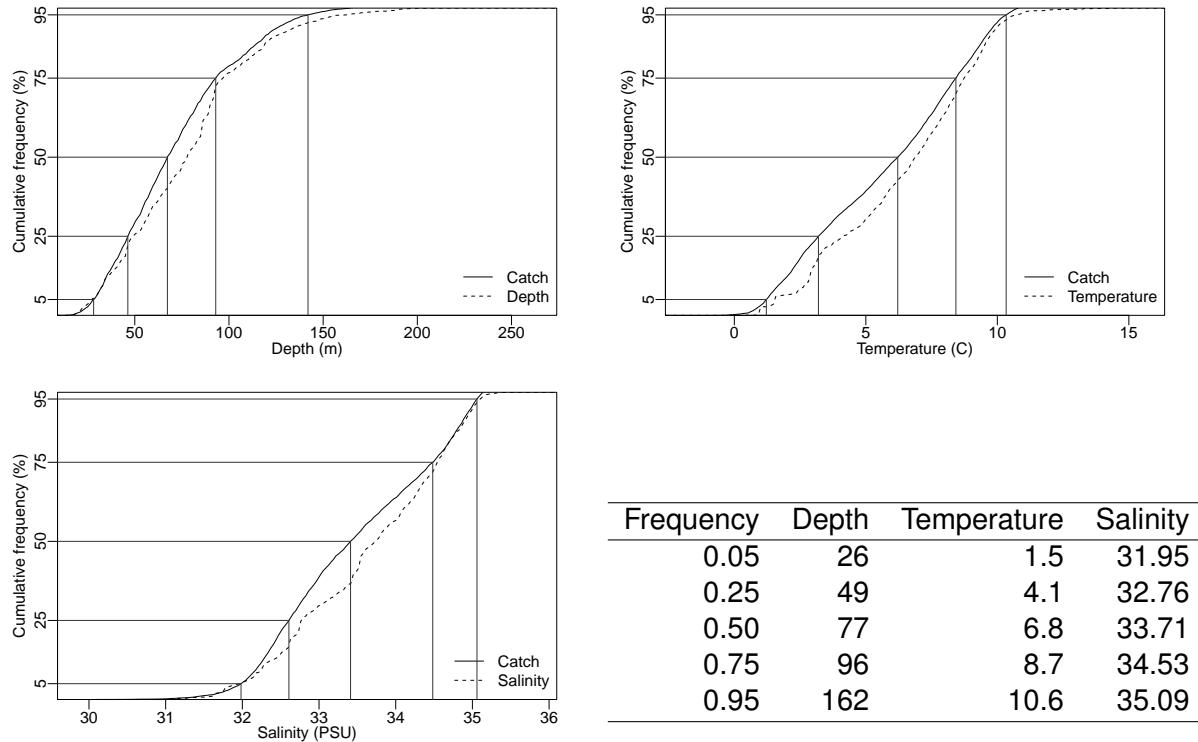


Figure 6.17E. Catch distribution by depth, temperature and salinity of Monkfish.

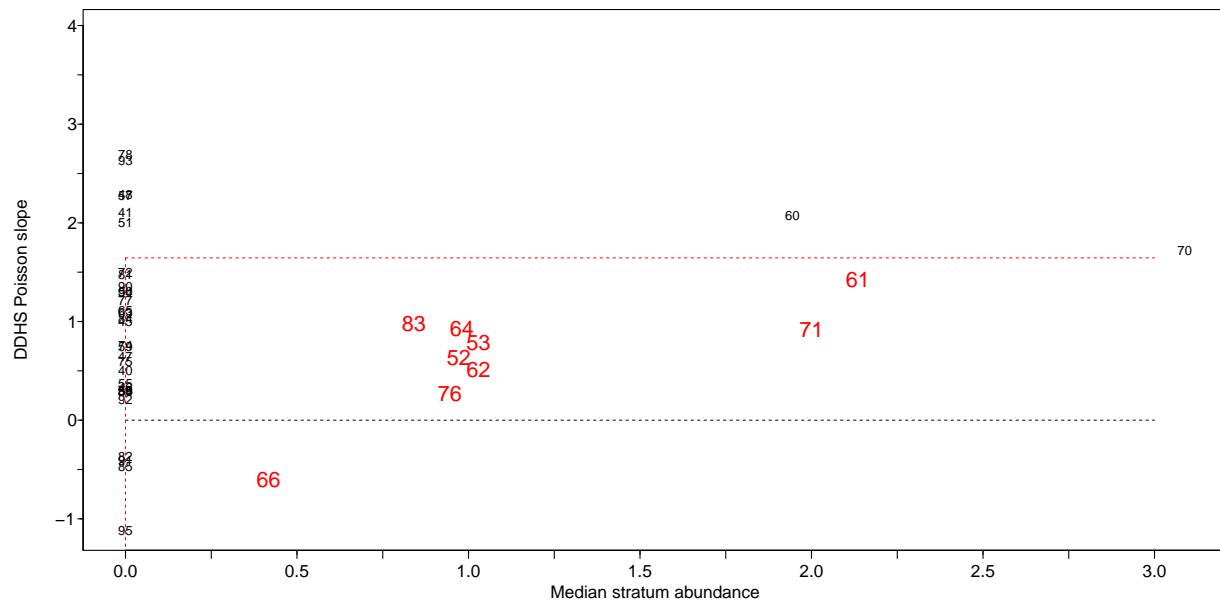


Figure 6.17F. DDHS slopes versus median stratum abundance for Monkfish. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.18 Thorny skate (Raie épineuse) - species code 201 (category LF)

Scientific name: [Amblyraja radiata](#)

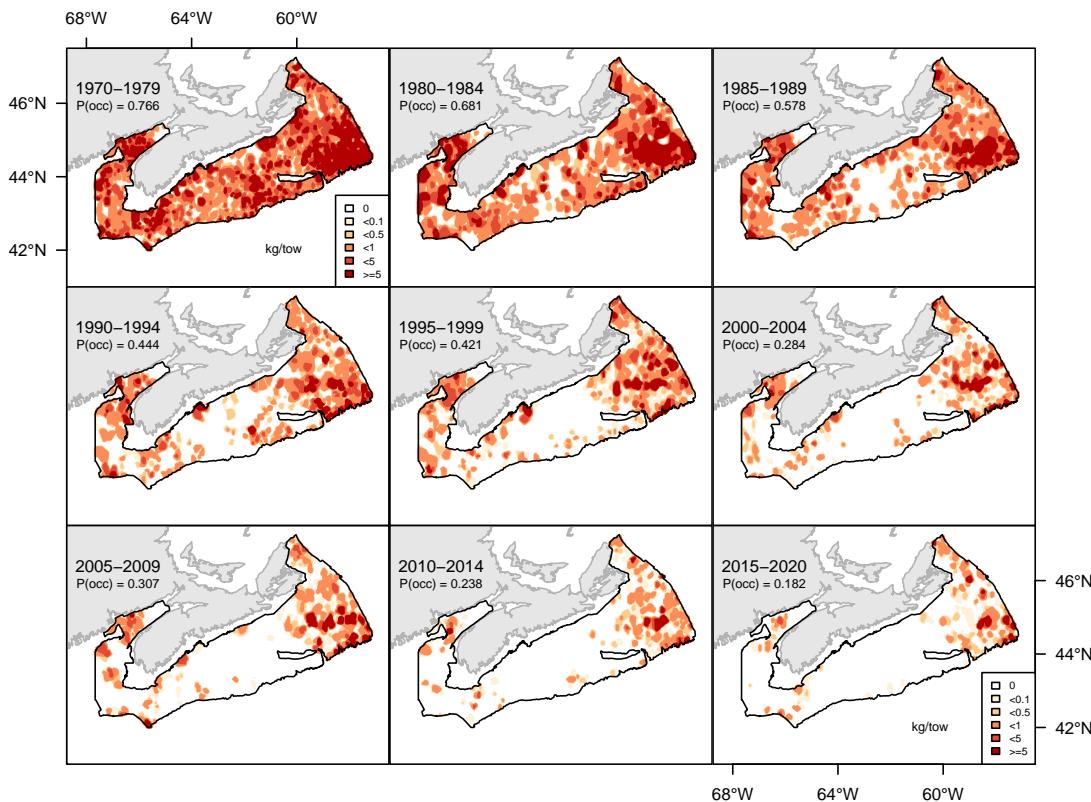


Figure 6.18A. Inverse distance weighted distribution of catch biomass (kg/tow) for Thorny skate. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

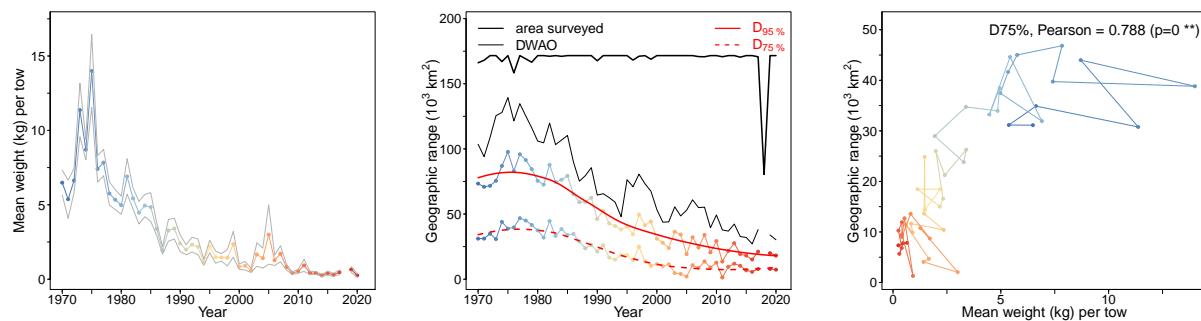


Figure 6.18B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Thorny skate. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

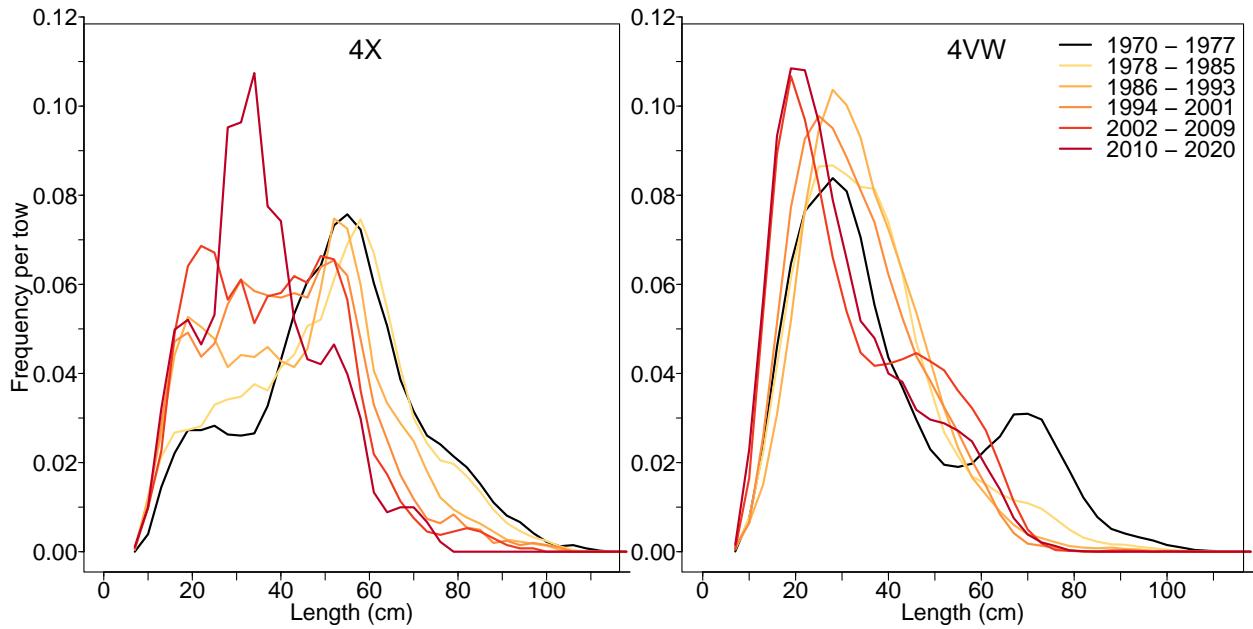


Figure 6.18C. Length frequency distribution in NAFO units 4X and 4VW for Thorny skate.

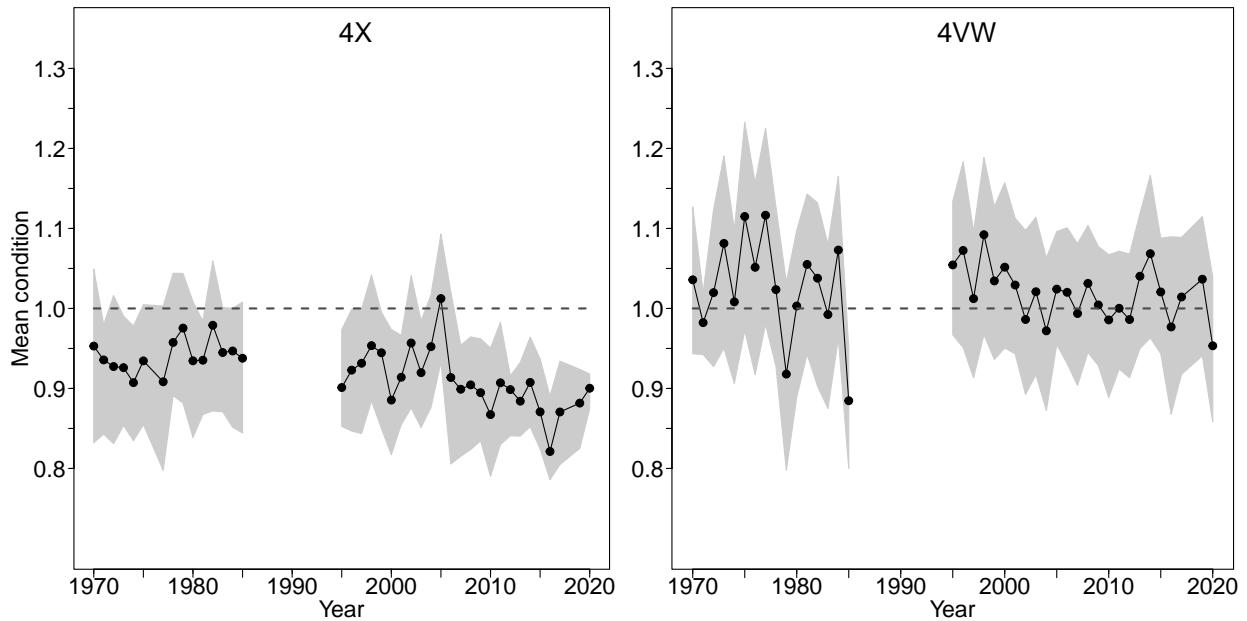


Figure 6.18D. Average fish condition in NAFO units 4X and 4VW for Thorny skate.

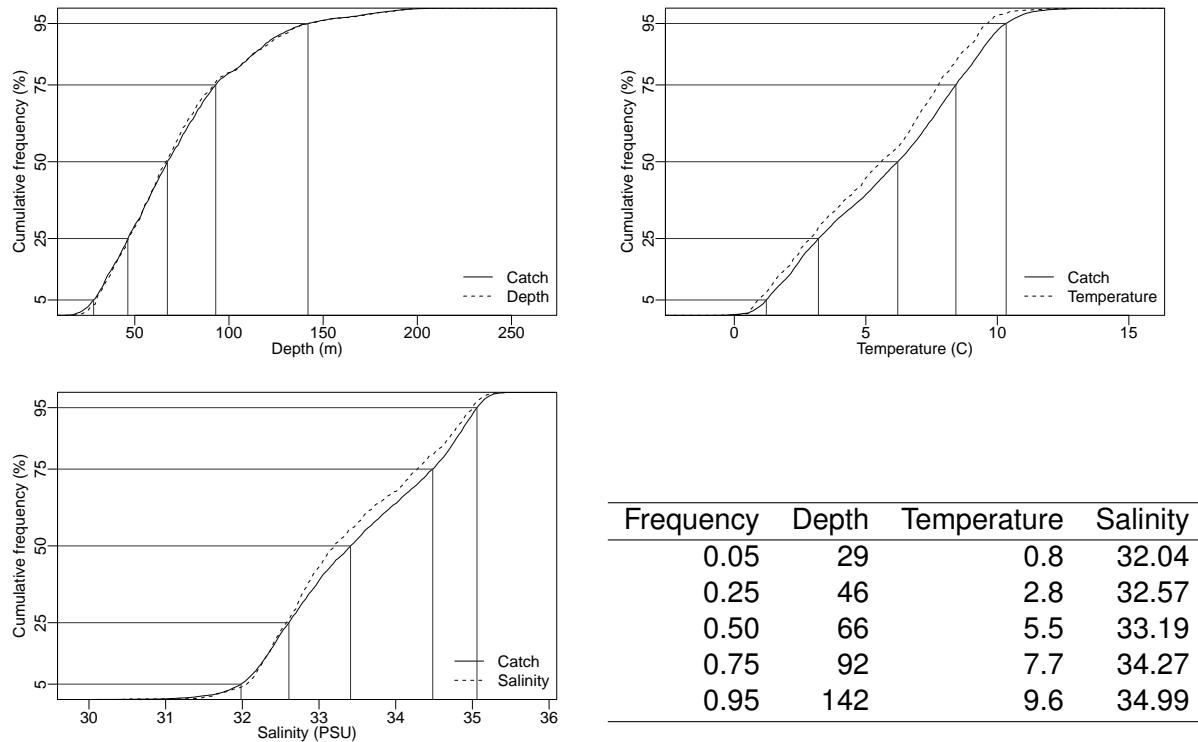


Figure 6.18E. Catch distribution by depth, temperature and salinity of Thorny skate.

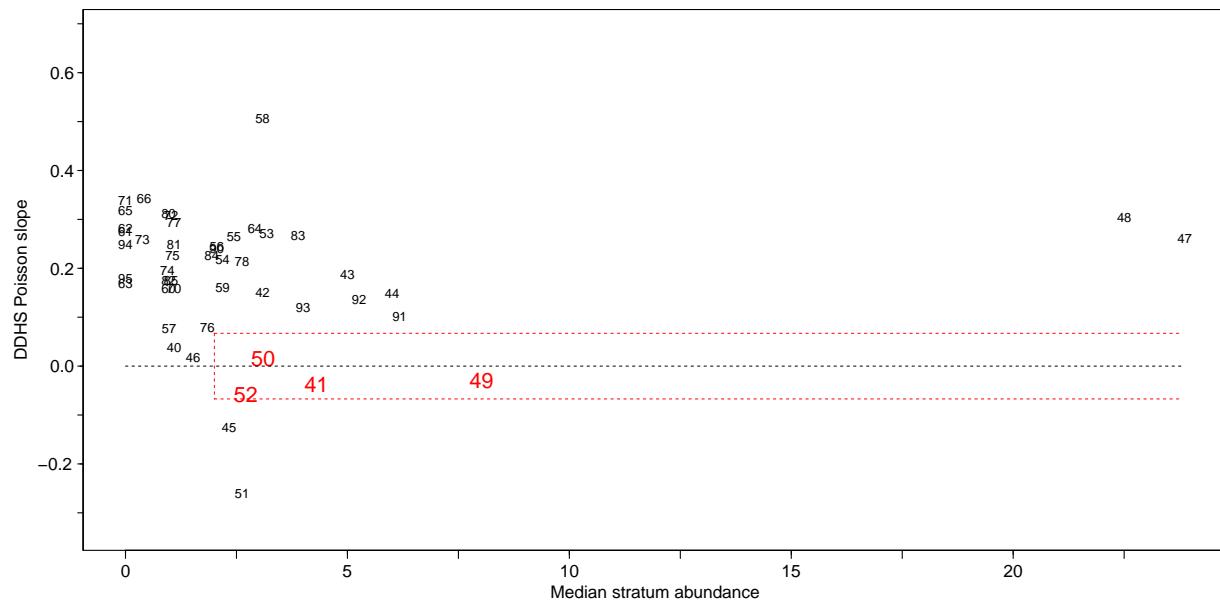


Figure 6.18F. DDHS slopes versus median stratum abundance for Thorny skate. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.19 Smooth skate (Raie lisse) - species code 202 (category LF)

Scientific name: [Malacoraja senta](#)

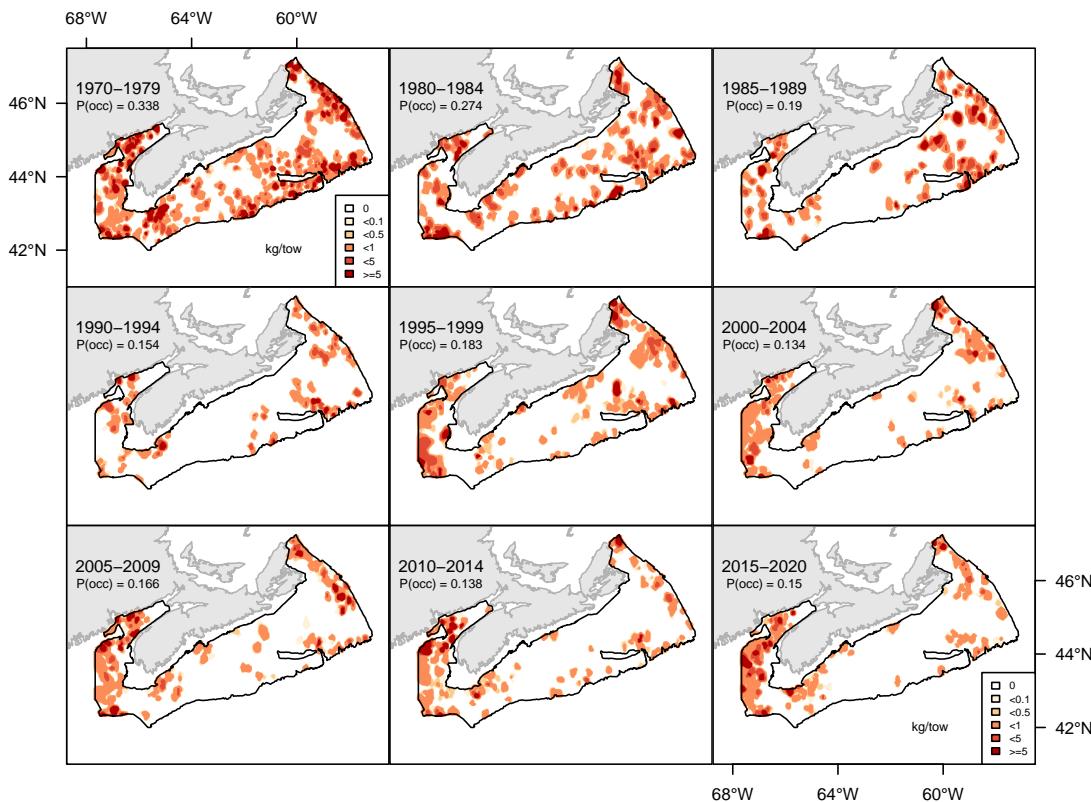


Figure 6.19A. Inverse distance weighted distribution of catch biomass (kg/tow) for Smooth skate. $P(\text{occ})$ is the proportion of tugs with catch records for each 5-year period.

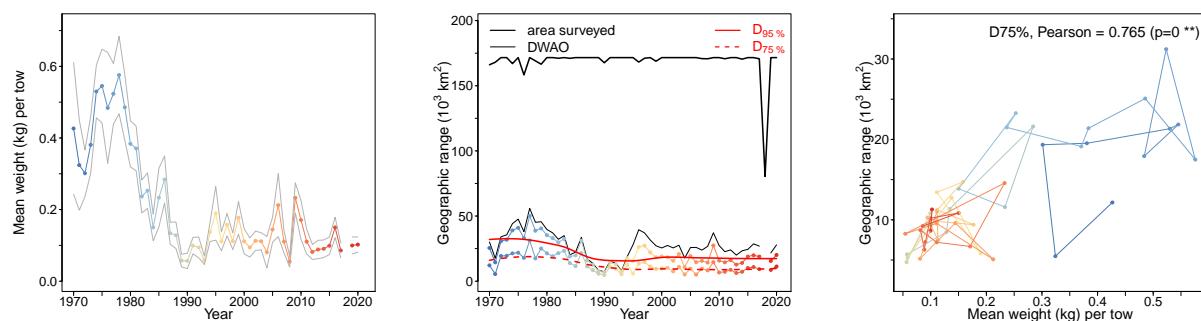


Figure 6.19B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Smooth skate. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

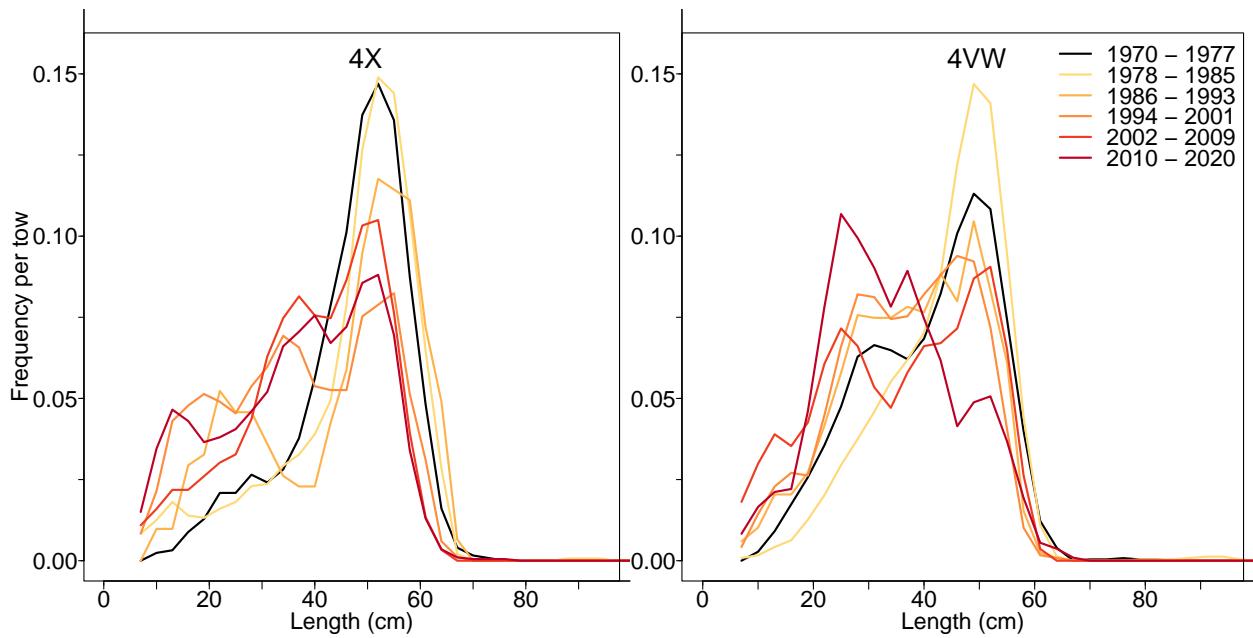


Figure 6.19C. Length frequency distribution in NAFO units 4X and 4VW for Smooth skate.

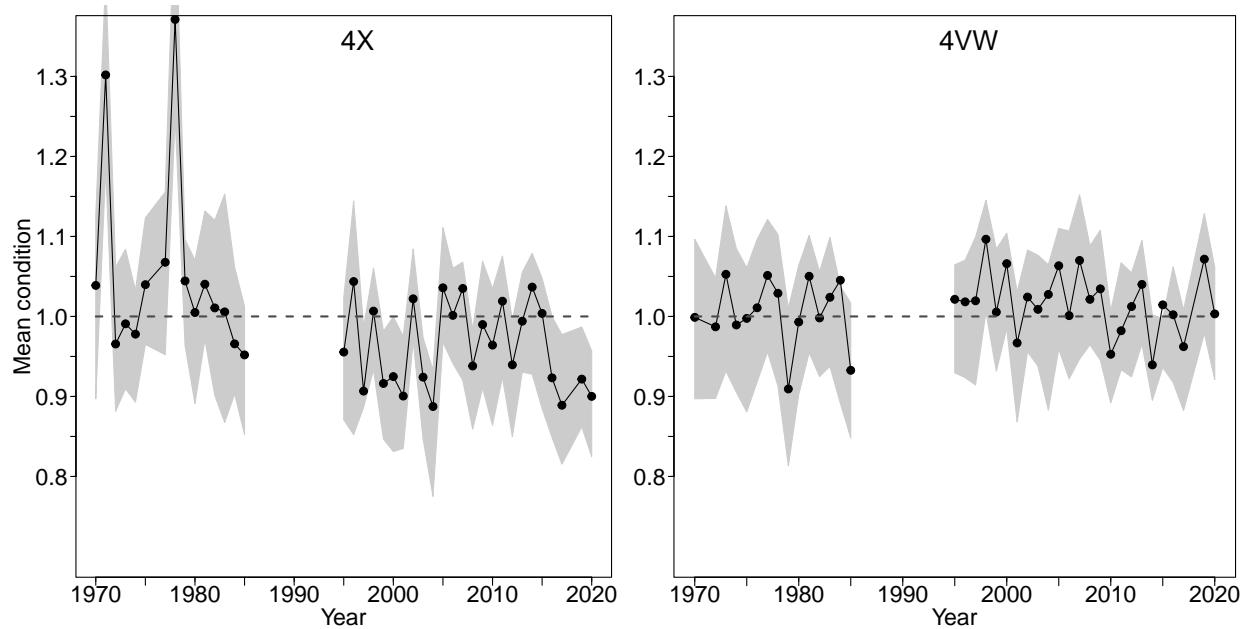


Figure 6.19D. Average fish condition in NAFO units 4X and 4VW for Smooth skate.

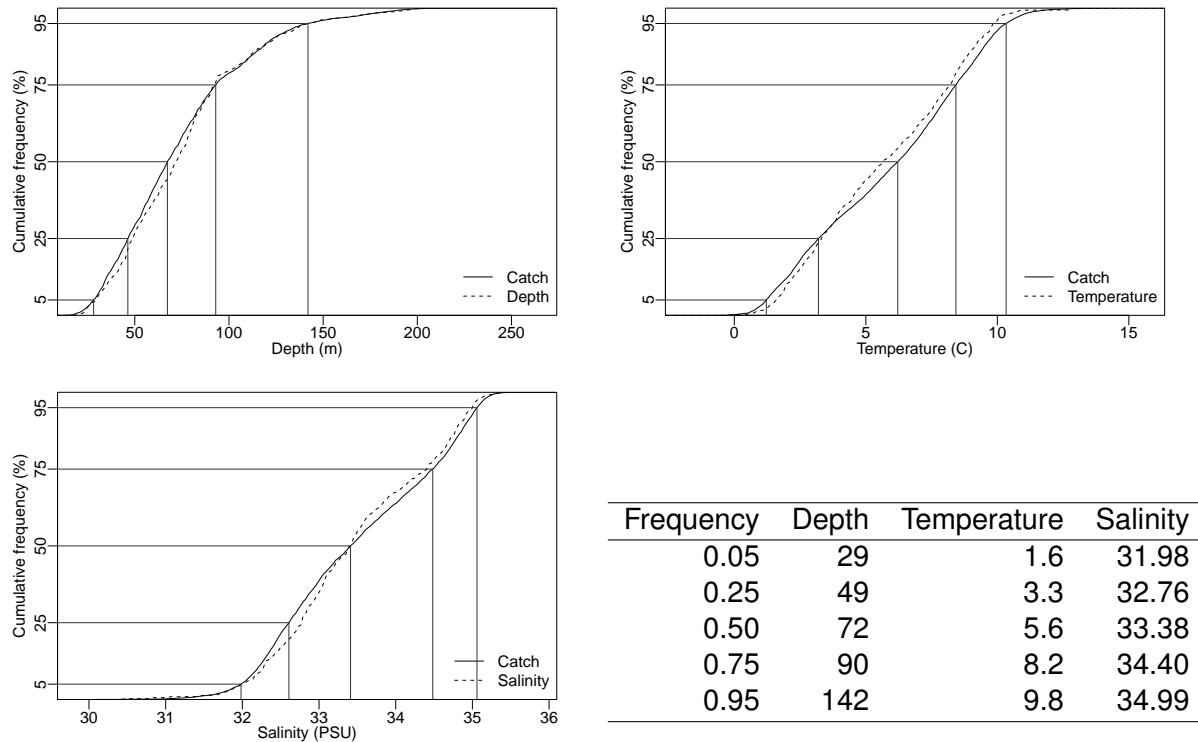


Figure 6.19E. Catch distribution by depth, temperature and salinity of Smooth skate.

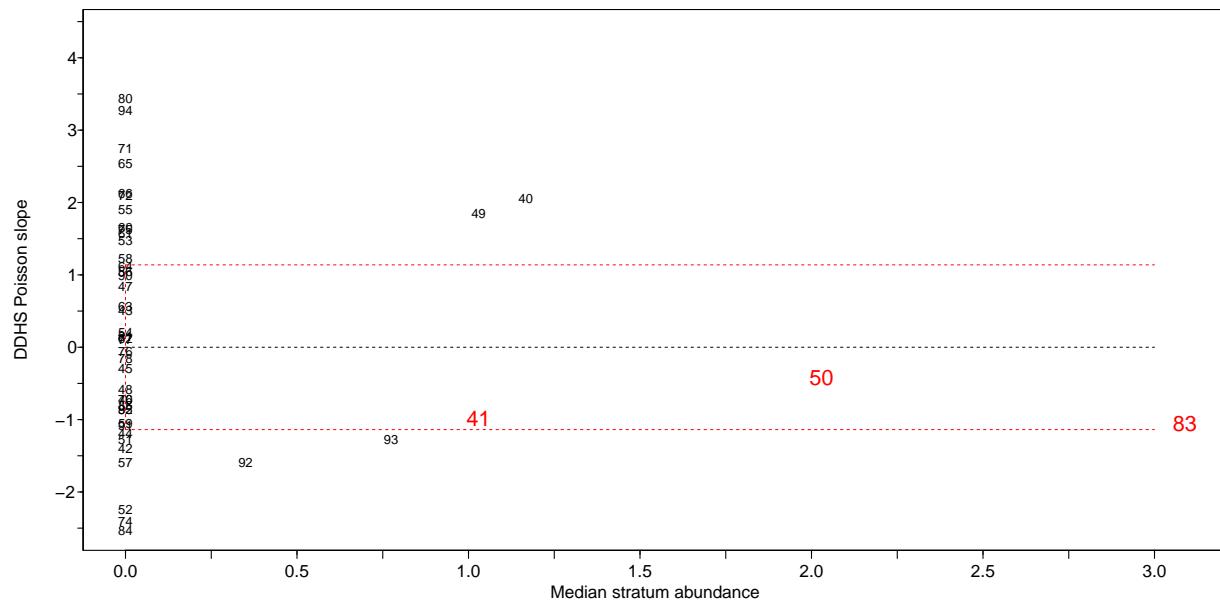


Figure 6.19F. DDHS slopes versus median stratum abundance for Smooth skate. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.20 Piked dogfish (Aiguillat commun) - species code 220 (category LF)

Scientific name: [Squalus acanthias](#)

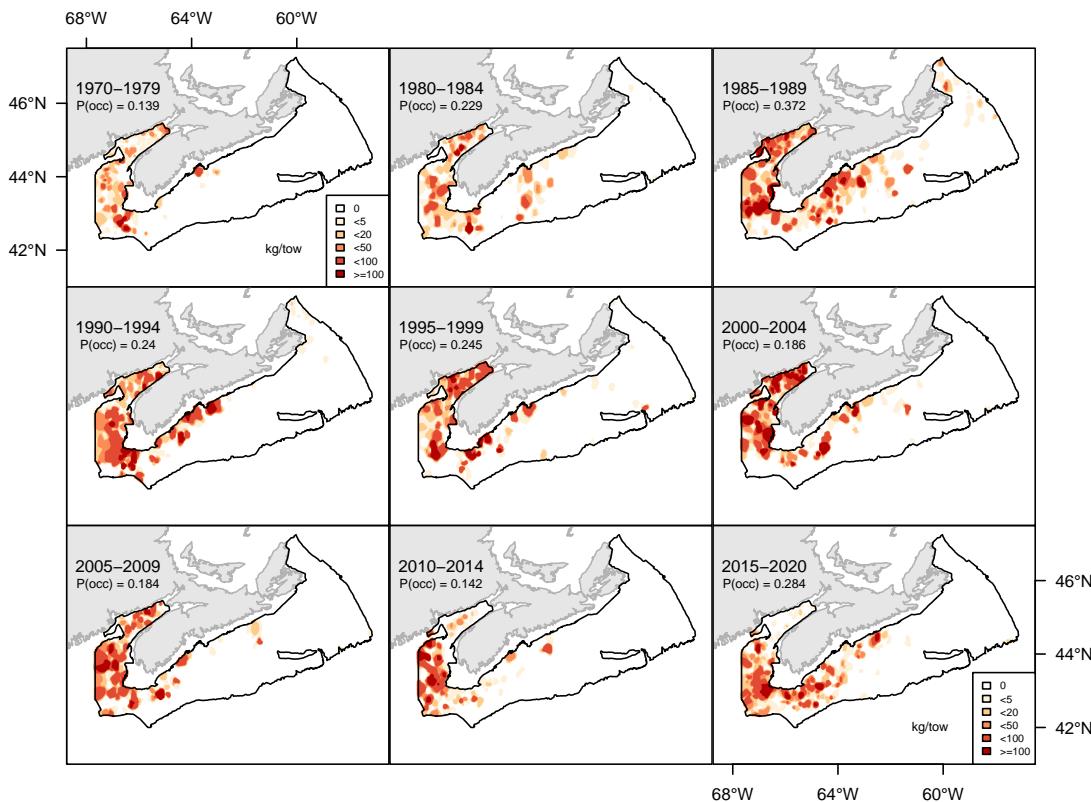


Figure 6.20A. Inverse distance weighted distribution of catch biomass (kg/tow) for Piked dogfish. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

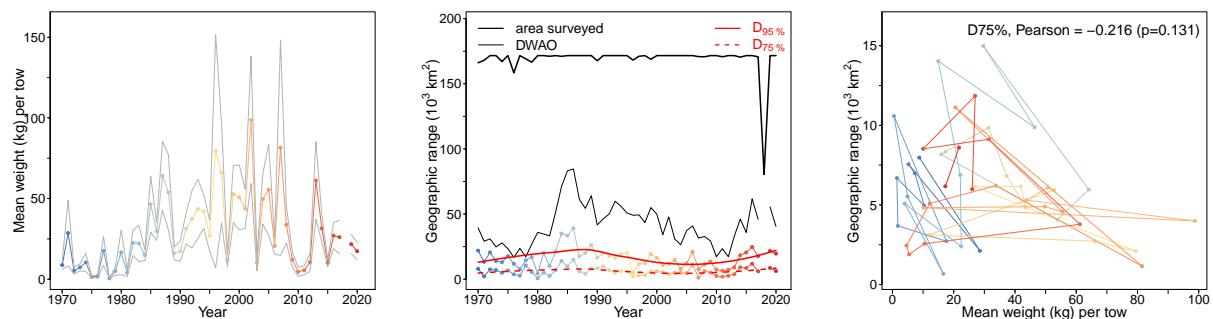


Figure 6.20B. Stratified random estimates of biomass (kg/tow), D₇₅ and D₉₅ and the correlation between D₇₅ and biomass of Piked dogfish. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

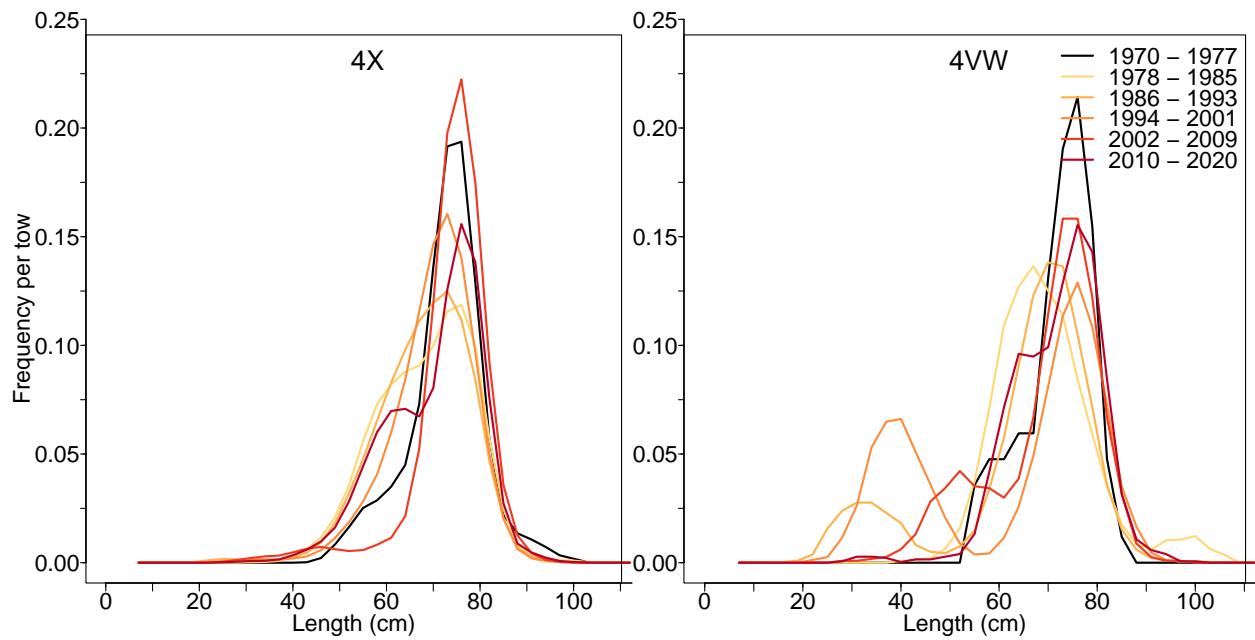


Figure 6.20C. Length frequency distribution in NAFO units 4X and 4VW for Piked dogfish.

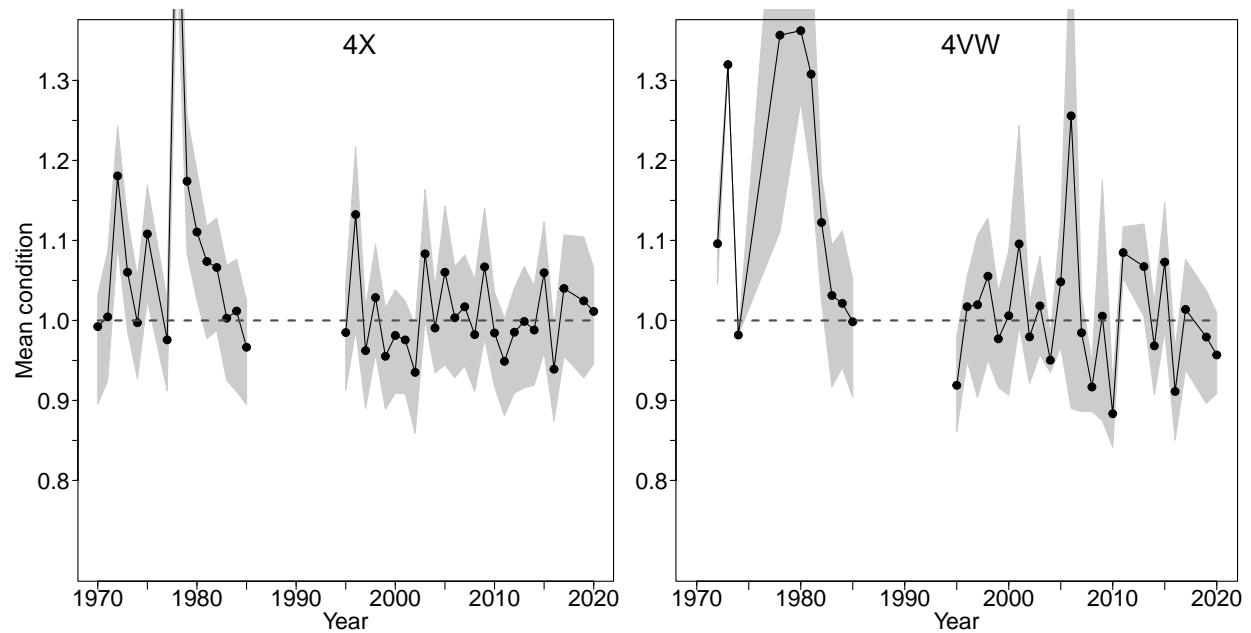


Figure 6.20D. Average fish condition in NAFO units 4X and 4VW for Piked dogfish.

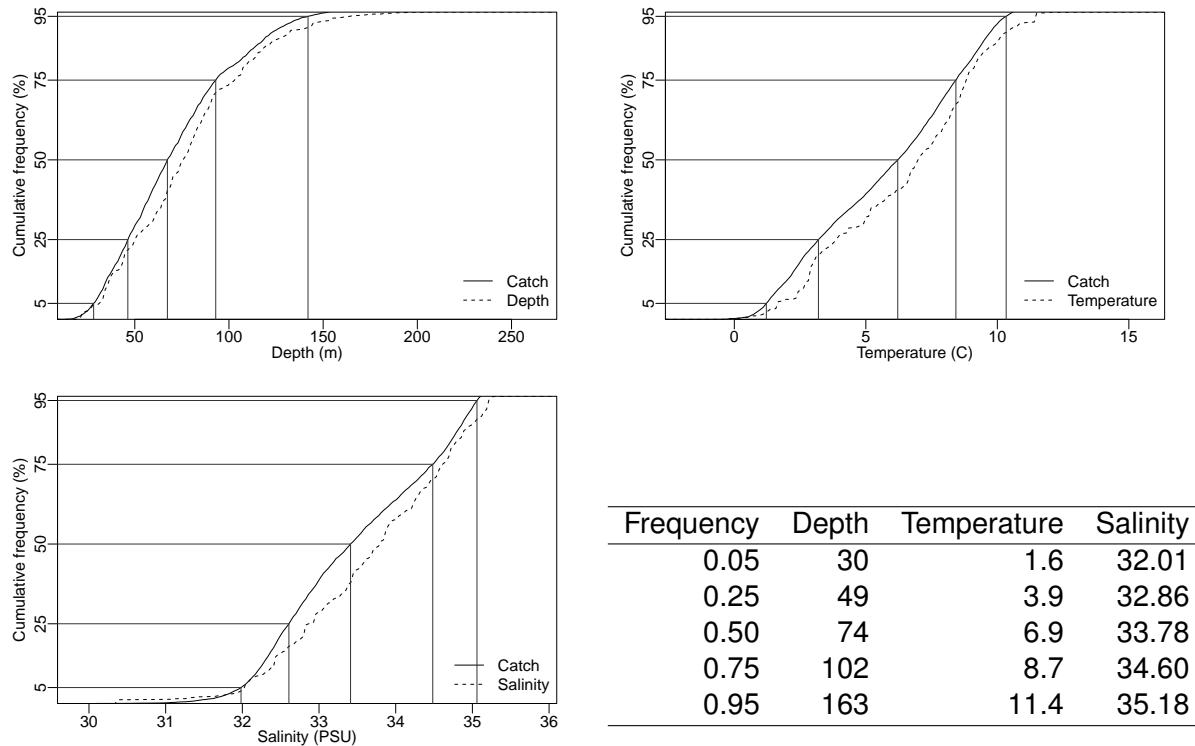
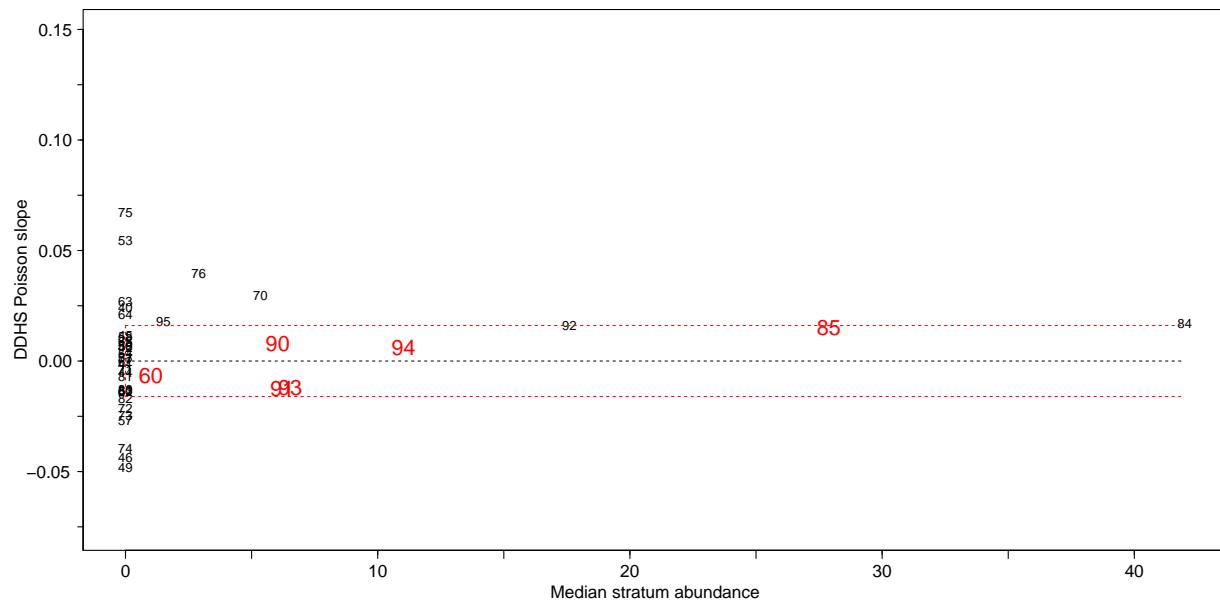


Figure 6.20E. Catch distribution by depth, temperature and salinity of Piked dogfish.



6.21 North. shortfin squid (*Encornet rouge nord.*) - species code 4511 (category LF)

Scientific name: [*Illex illecebrosus*](#)

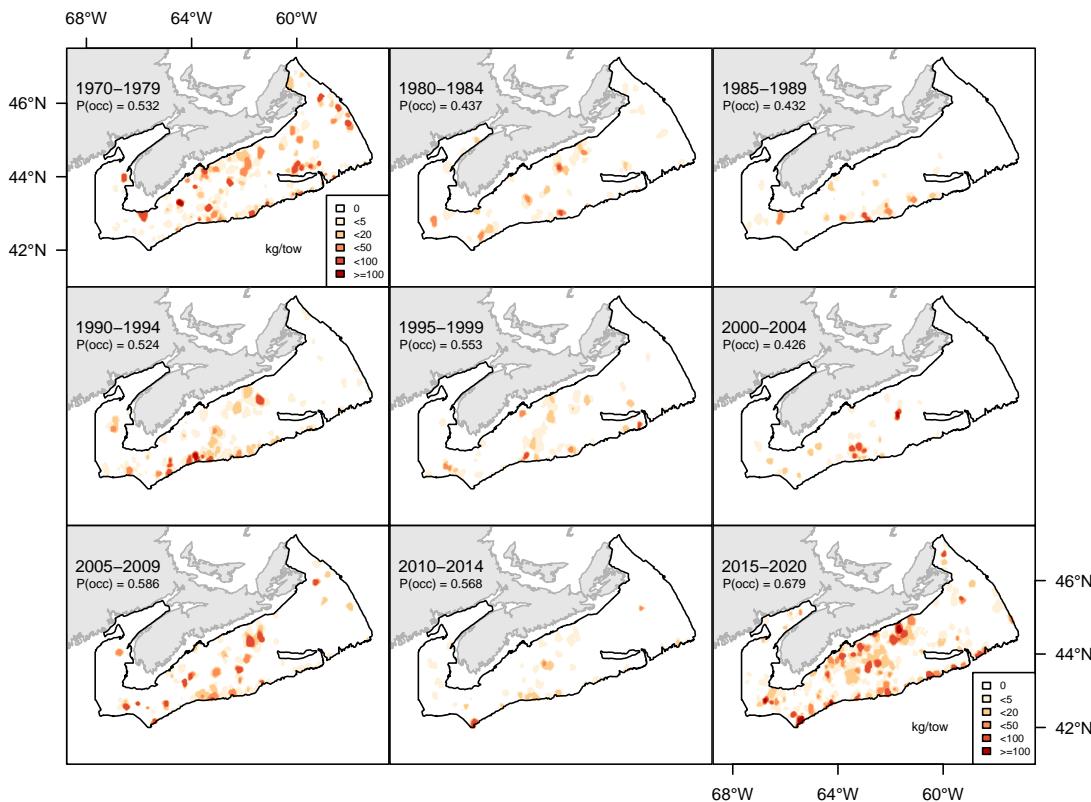


Figure 6.21A. Inverse distance weighted distribution of catch biomass (kg/tow) for North. shortfin squid. $P(\text{occ})$ is the proportion of tows with catch records for each 5-year period.

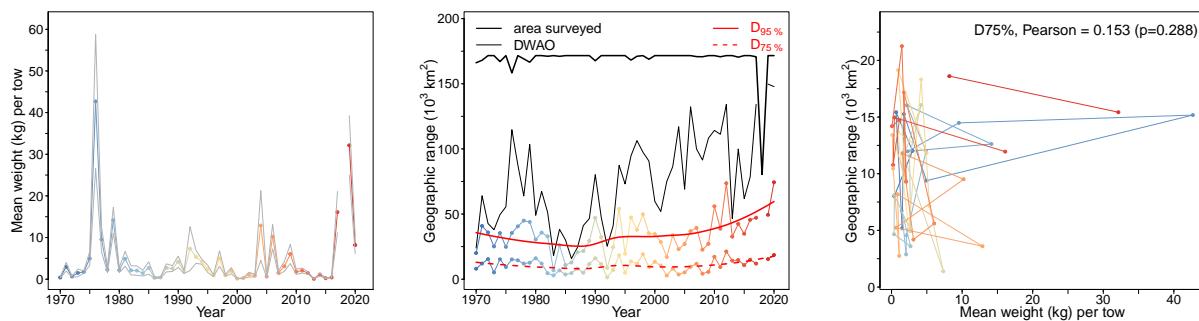


Figure 6.21B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of North. shortfin squid. The predictions from a loess estimator are overlaid on the distribution indices in the middle panel.

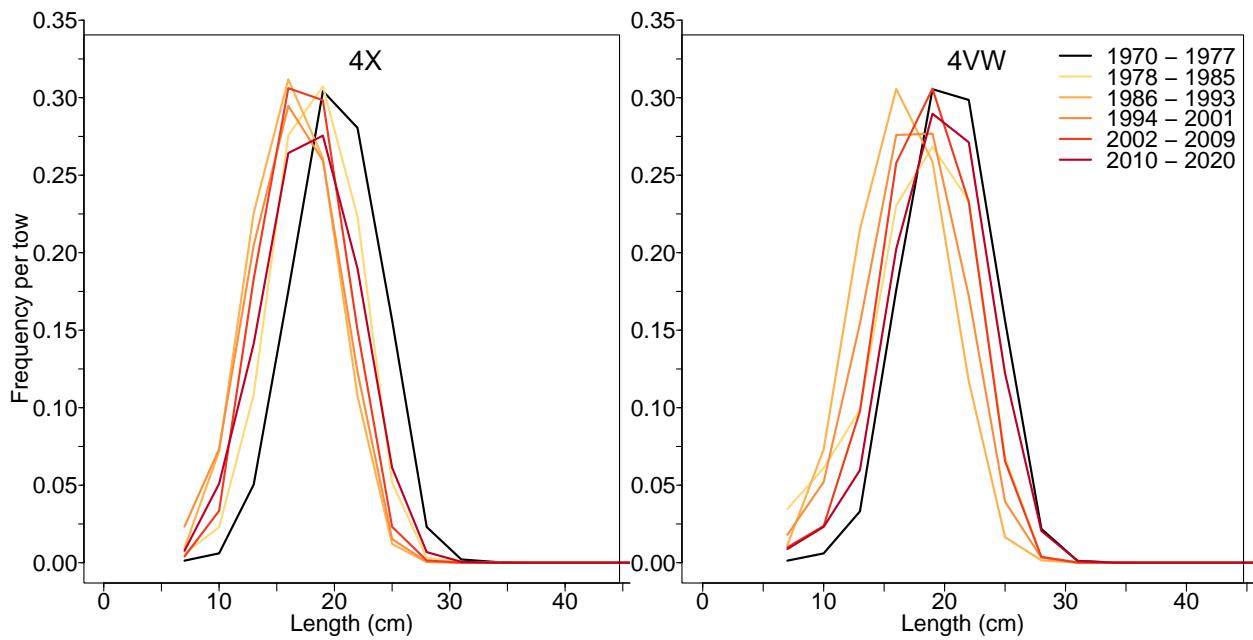


Figure 6.21C. Length frequency distribution in NAFO units 4X and 4VW for North. shortfin squid.

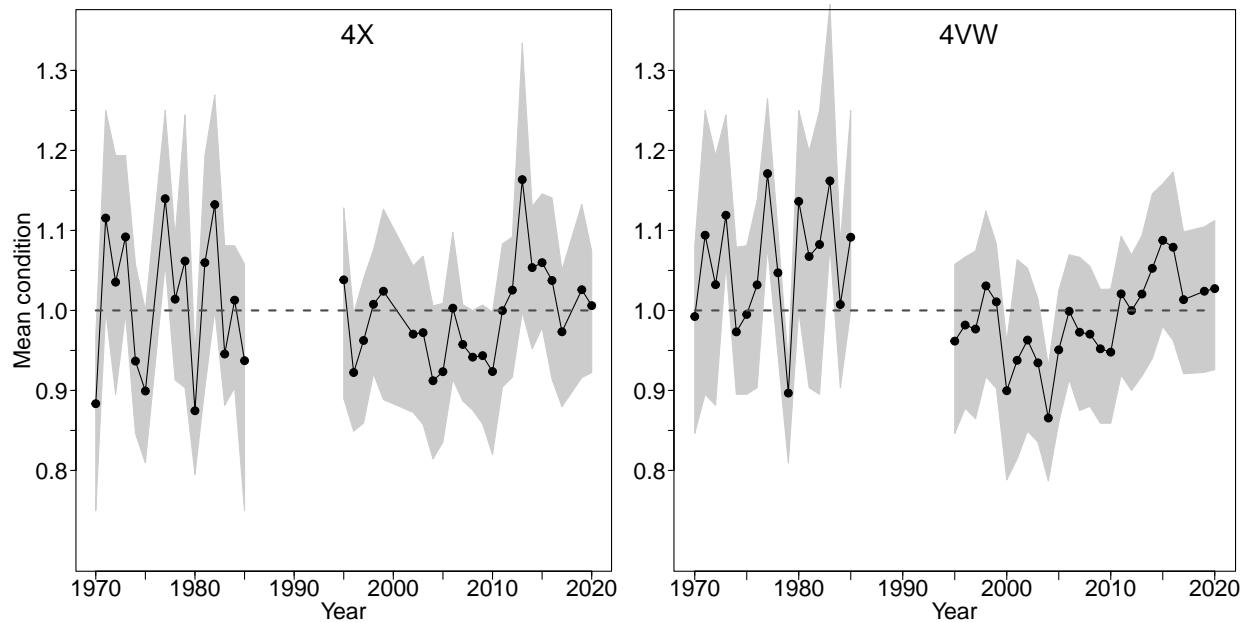


Figure 6.21D. Average fish condition in NAFO units 4X and 4VW for North. shortfin squid.

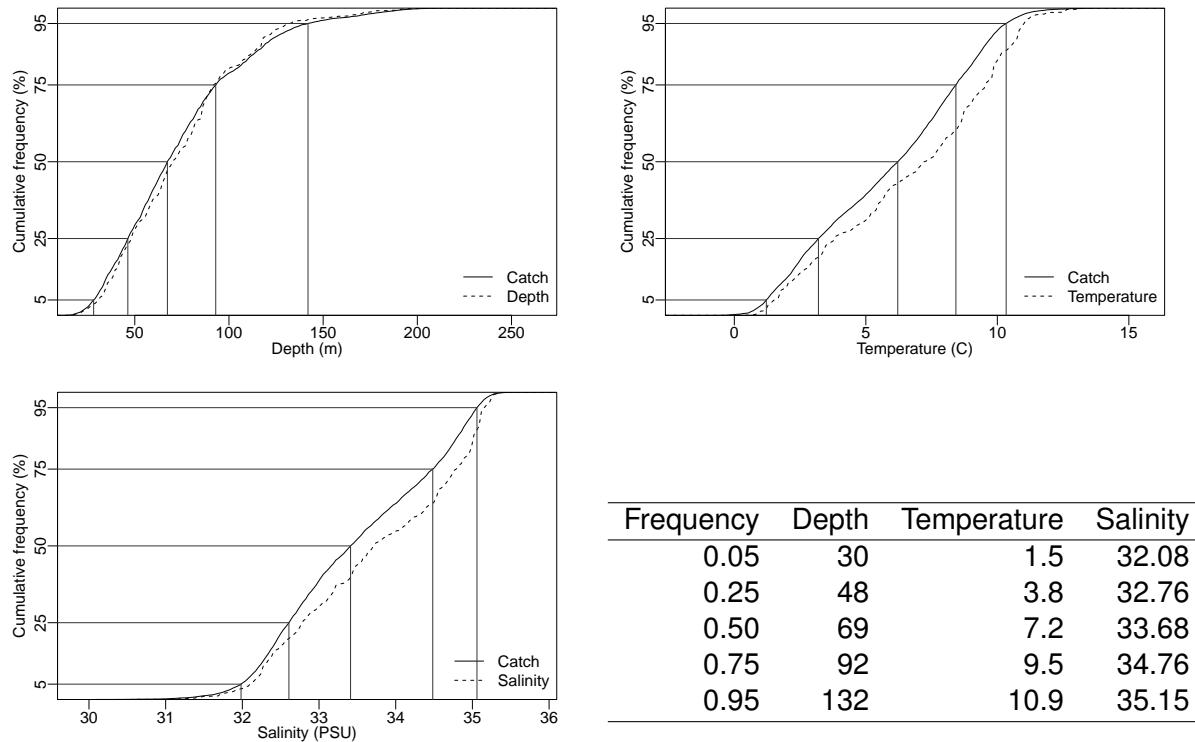


Figure 6.21E. Catch distribution by depth, temperature and salinity of North. shortfin squid.

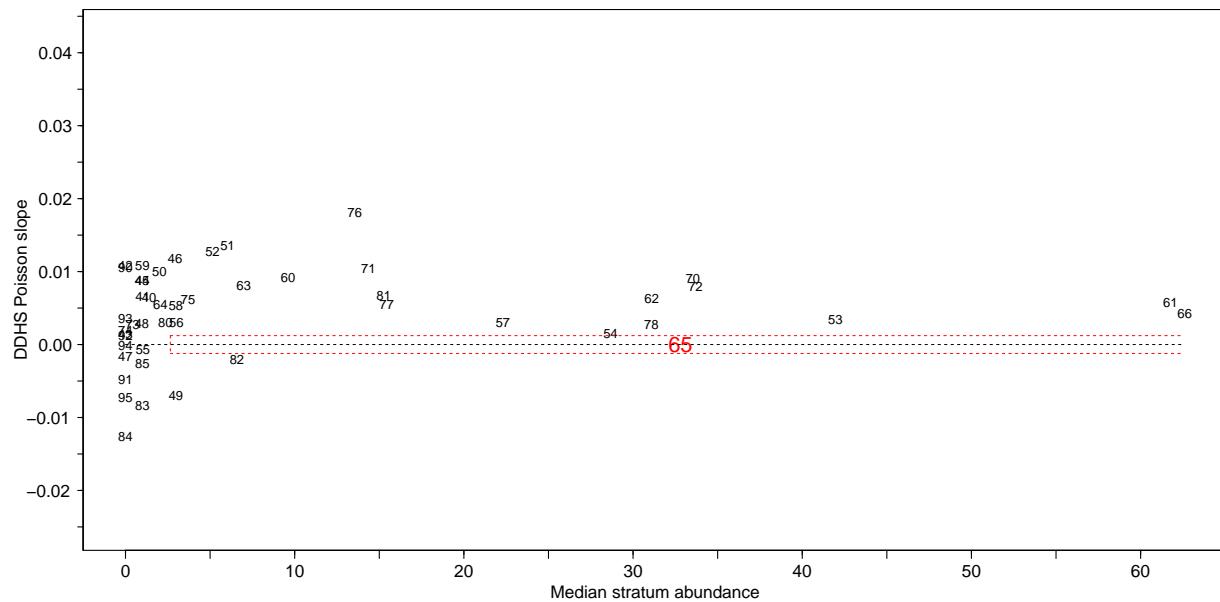


Figure 6.21F. DDHS slopes versus median stratum abundance for North. shortfin squid. The last two digits of each stratum number is shown in the figure. The red box indicates strata of particular importance for a species by identifying slopes that are within a standard error from zero and that are within the top 25% of median abundance.

6.22 Atlantic hagfish (*Myxine du nord*) - species code 241 (category LI)

Scientific name: [*Myxine glutinosa*](#)

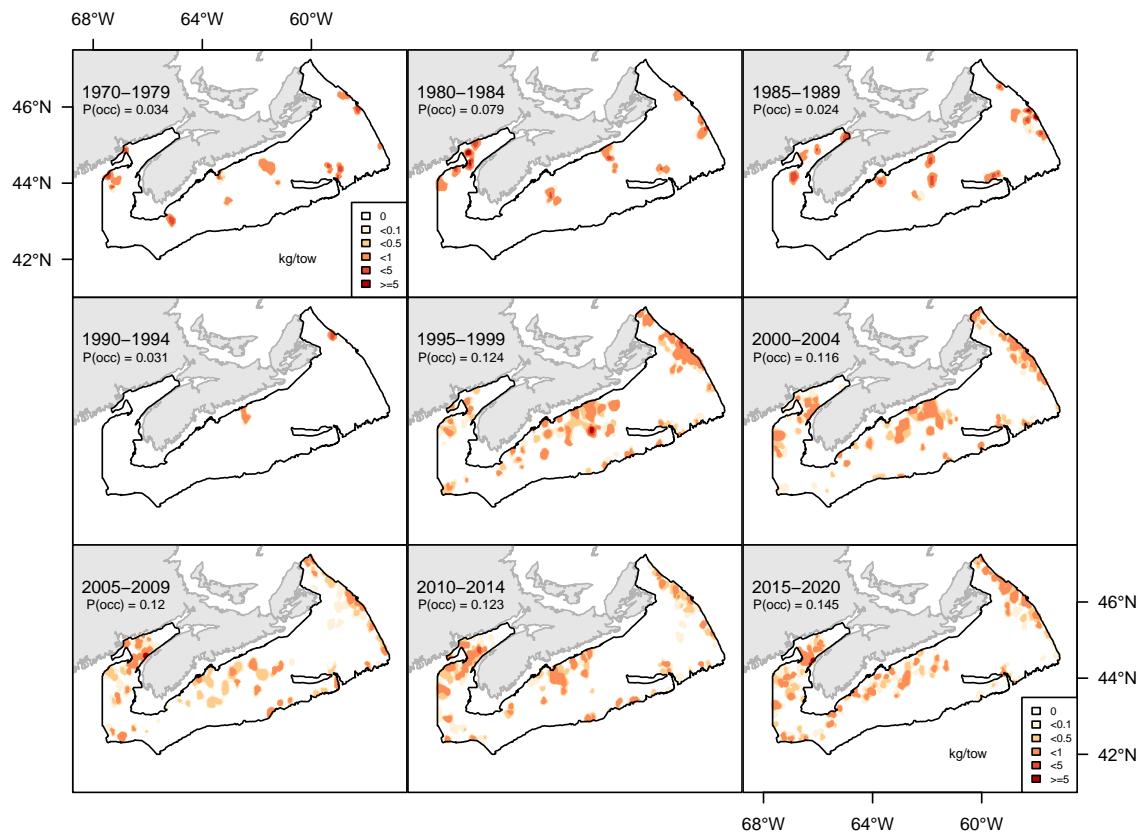


Figure 6.22A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic hagfish.

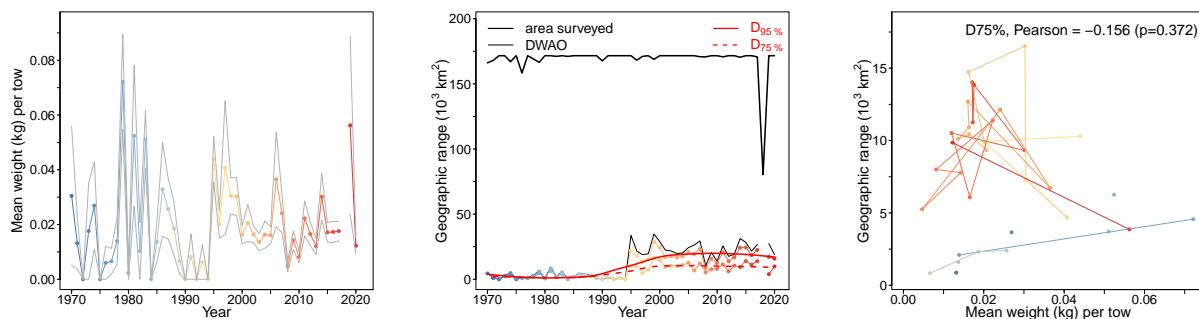


Figure 6.22B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hagfish.

6.23 Cusk (Brosme) - species code 15 (category LI)

Scientific name: [Brosme brosme](#)

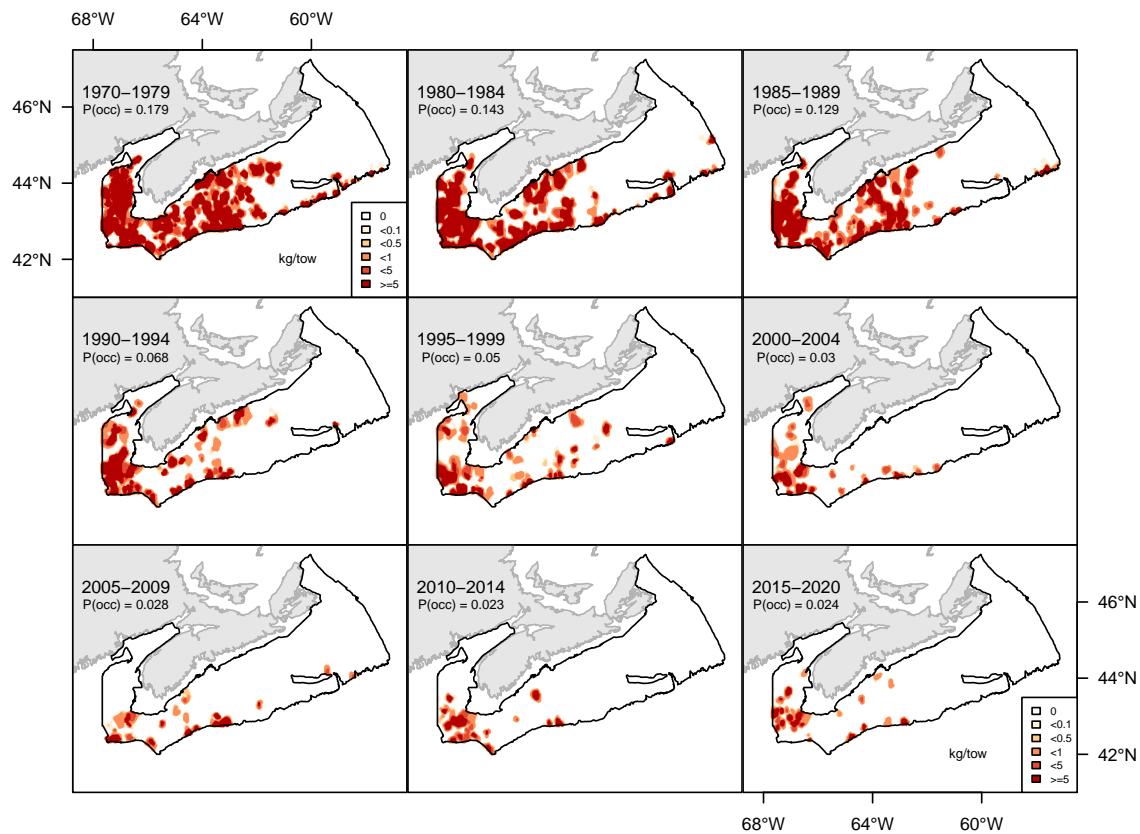


Figure 6.23A. Inverse distance weighted distribution of catch biomass (kg/tow) for Cusk.

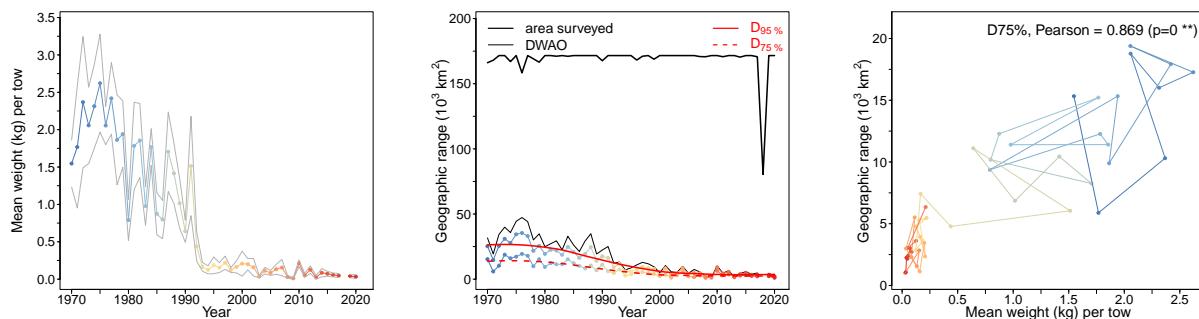


Figure 6.23B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Cusk.

6.24 Longfin hake (Merluche à longues nageoires) - species code 112 (category LI)

Scientific name: [Phycis chesteri](#)

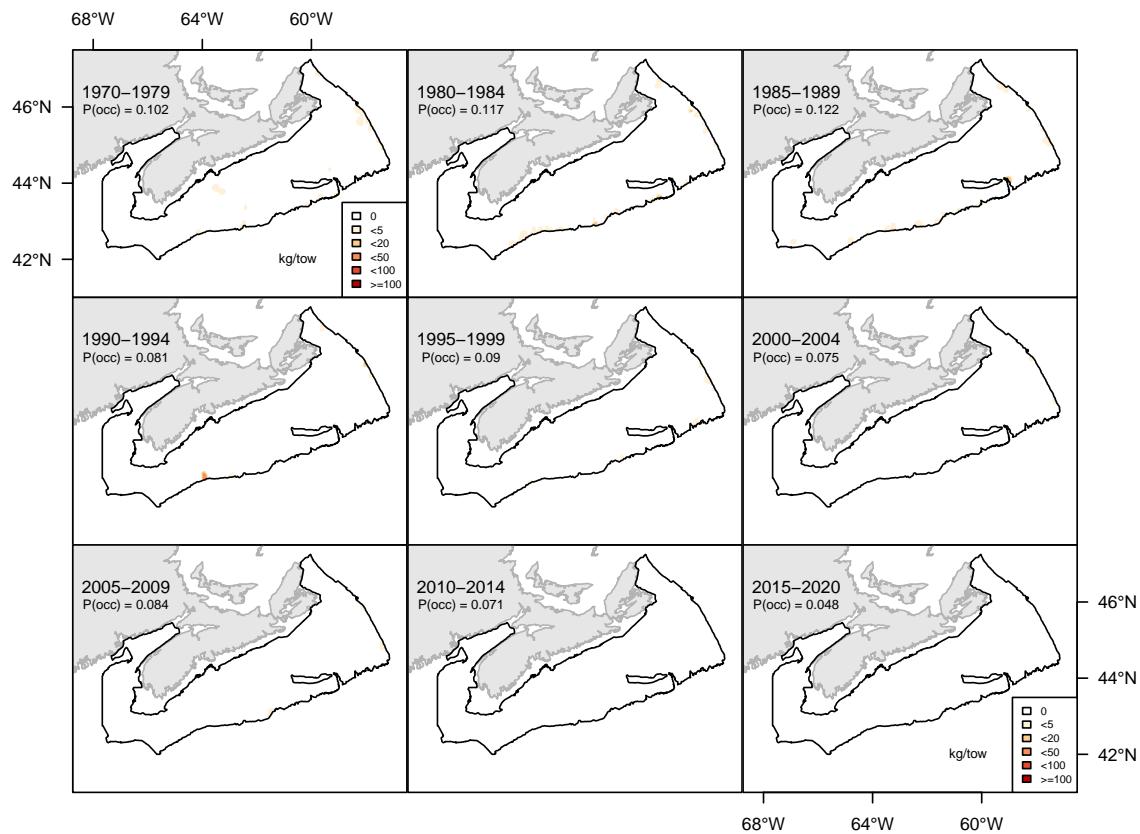


Figure 6.24A. Inverse distance weighted distribution of catch biomass (kg/tow) for Longfin hake.

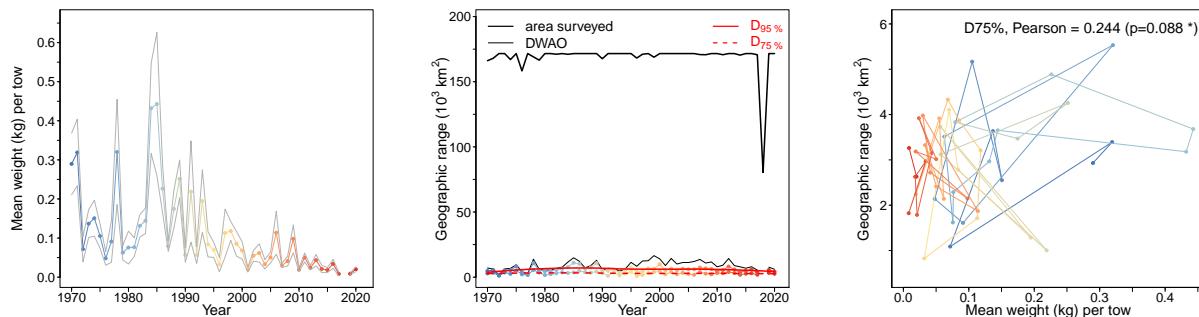


Figure 6.24B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Longfin hake.

6.25 Marlin-spike grenadier (Grenadier Grand Banc) - species code 410 (category LI)

Scientific name: [Nezumia bairdii](#)

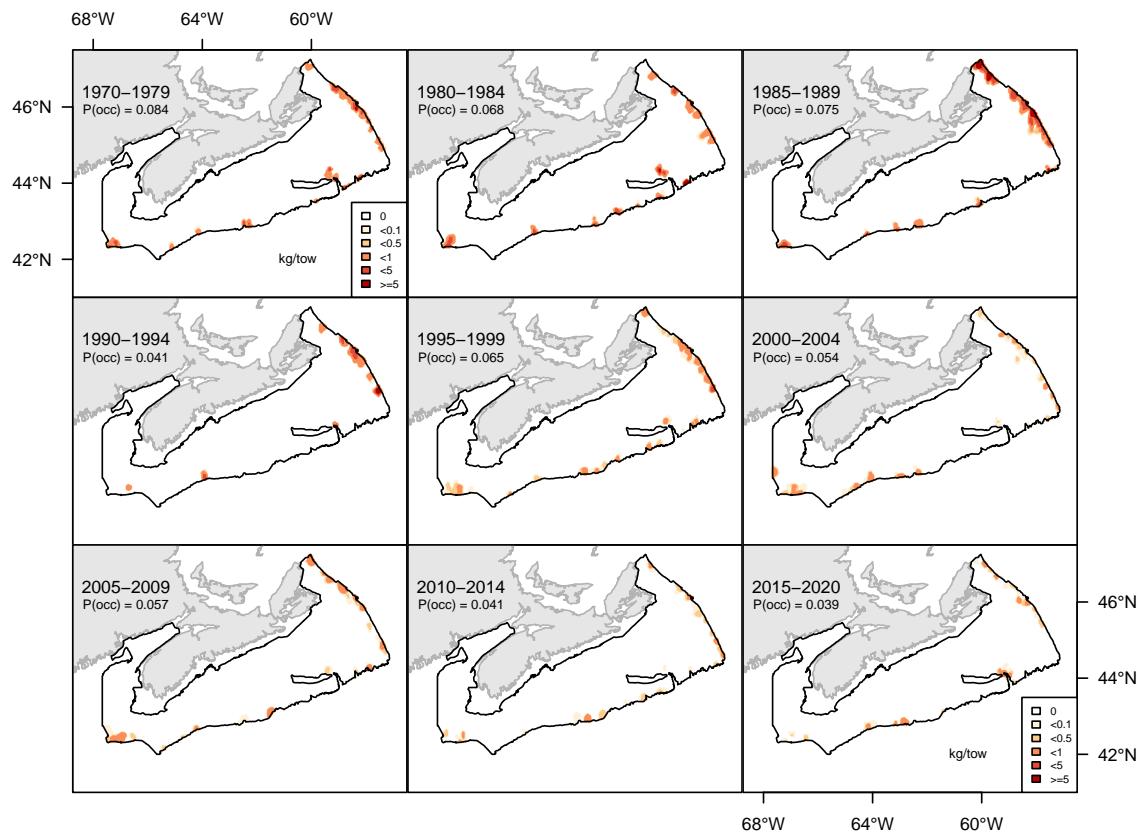


Figure 6.25A. Inverse distance weighted distribution of catch biomass (kg/tow) for Marlin-spike grenadier.

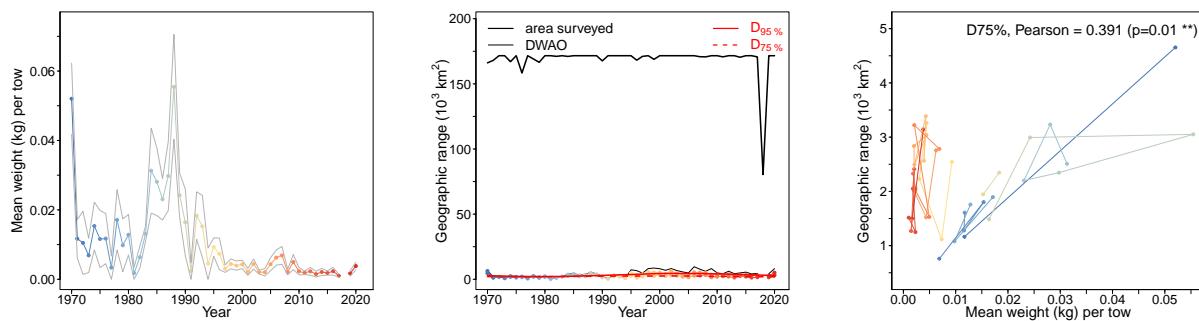


Figure 6.25B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Marlin-spike grenadier.

6.26 Moustache sculpin (Faux-trigle armé) - species code 304 (category LI)

Scientific name: [Triglops murrayi](#)

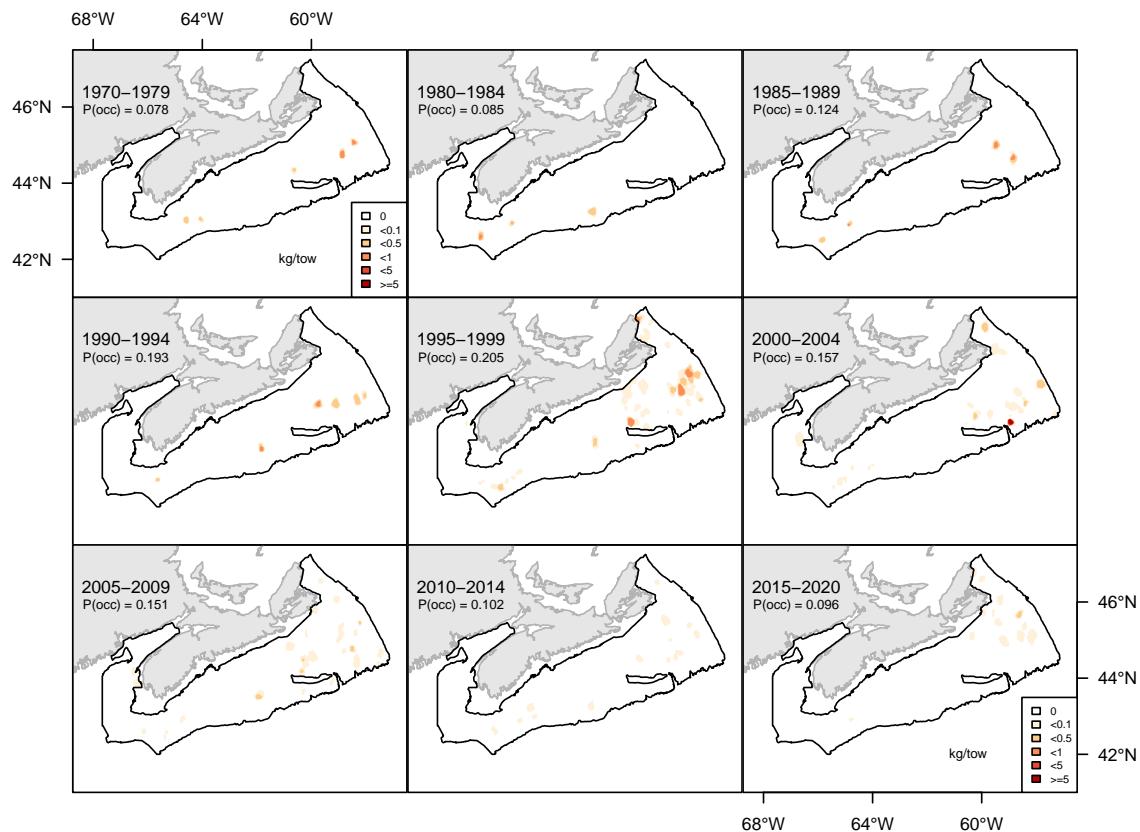


Figure 6.26A. Inverse distance weighted distribution of catch biomass (kg/tow) for Moustache sculpin.

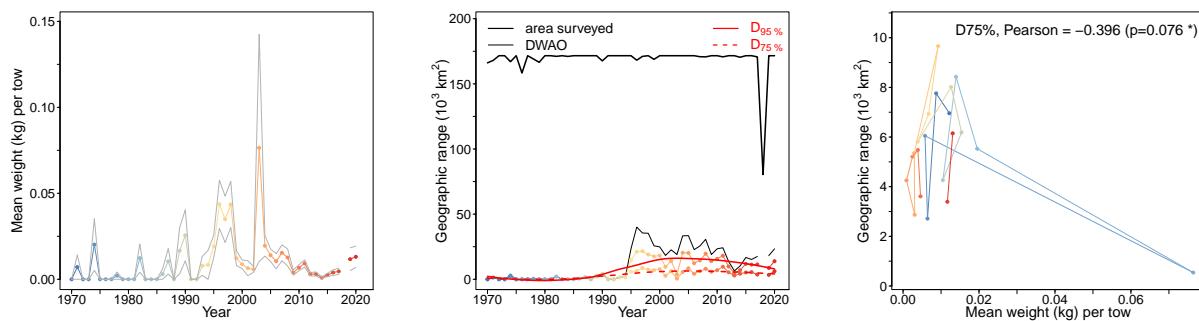


Figure 6.26B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Moustache sculpin.

6.27 Lumpfish (Lompe) - species code 501 (category LI)

Scientific name: [Cyclopterus lumpus](#)

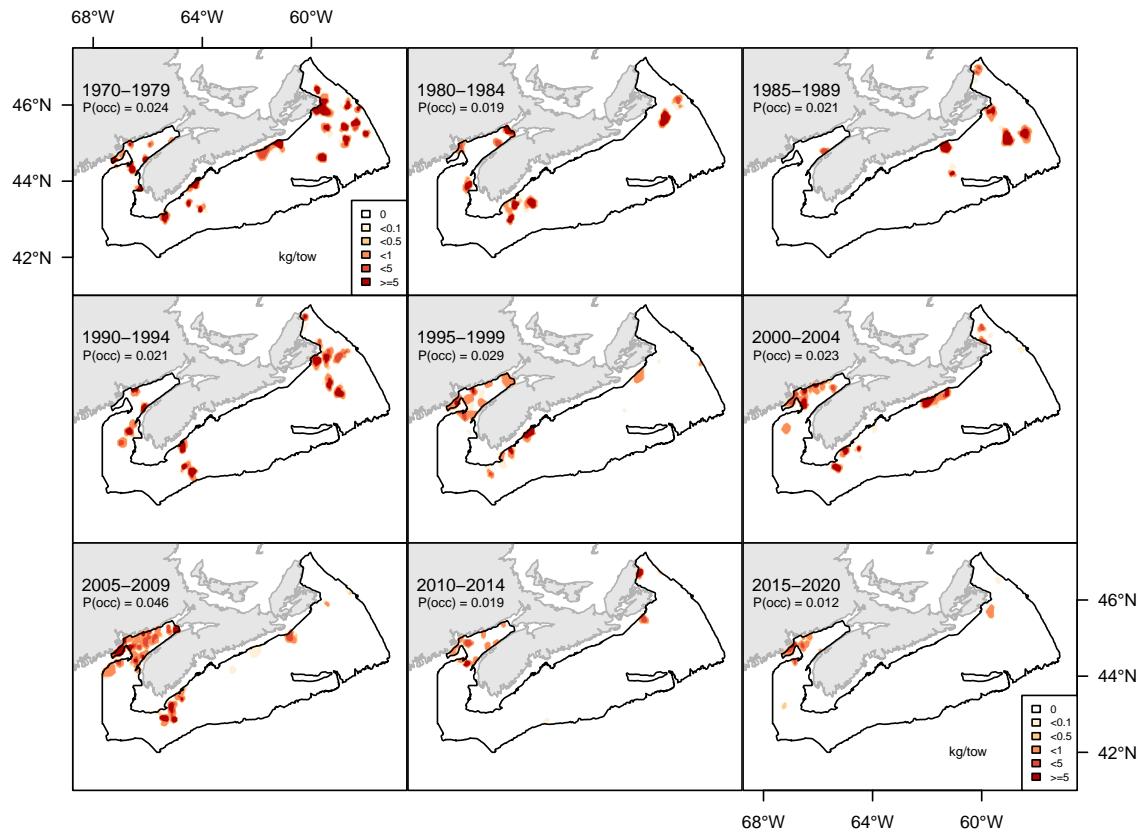


Figure 6.27A. Inverse distance weighted distribution of catch biomass (kg/tow) for Lumpfish.

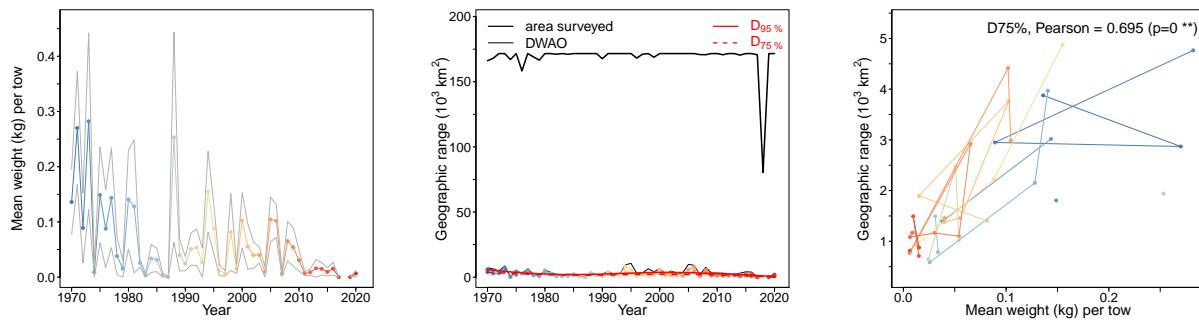


Figure 6.27B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Lumpfish.

6.28 Ocean pout (Loquette d'Amérique) - species code 640 (category LI)

Scientific name: [Zoarces americanus](#)

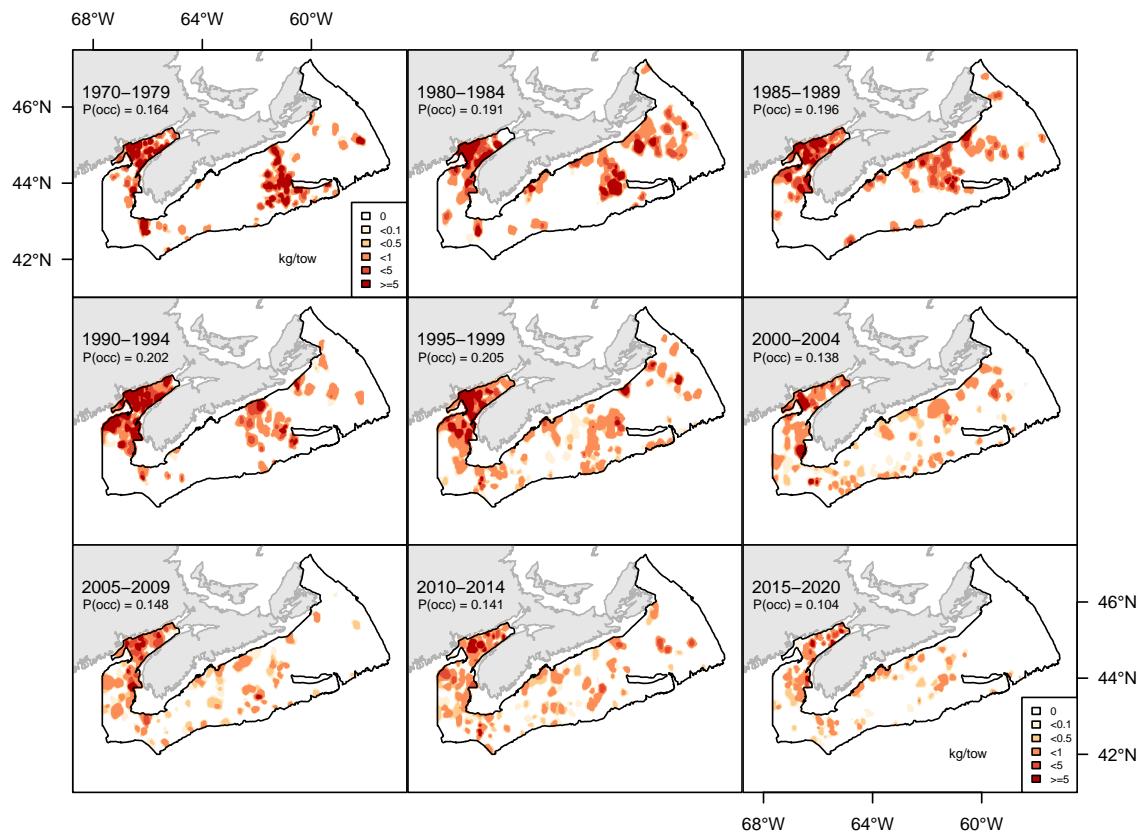


Figure 6.28A. Inverse distance weighted distribution of catch biomass (kg/tow) for Ocean pout.

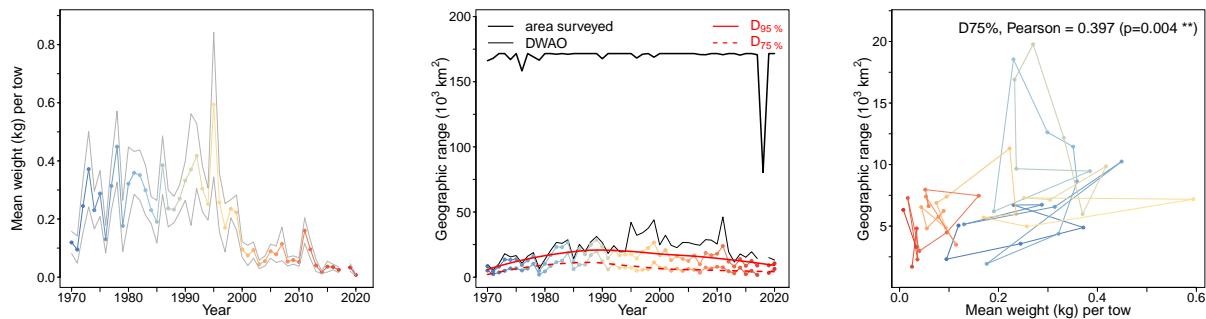


Figure 6.28B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Ocean pout.

6.29 Vahl's eelpout (*Lycodes vahlii*) - species code 647 (category LI)

Scientific name: [Lycodes vahlii](#)

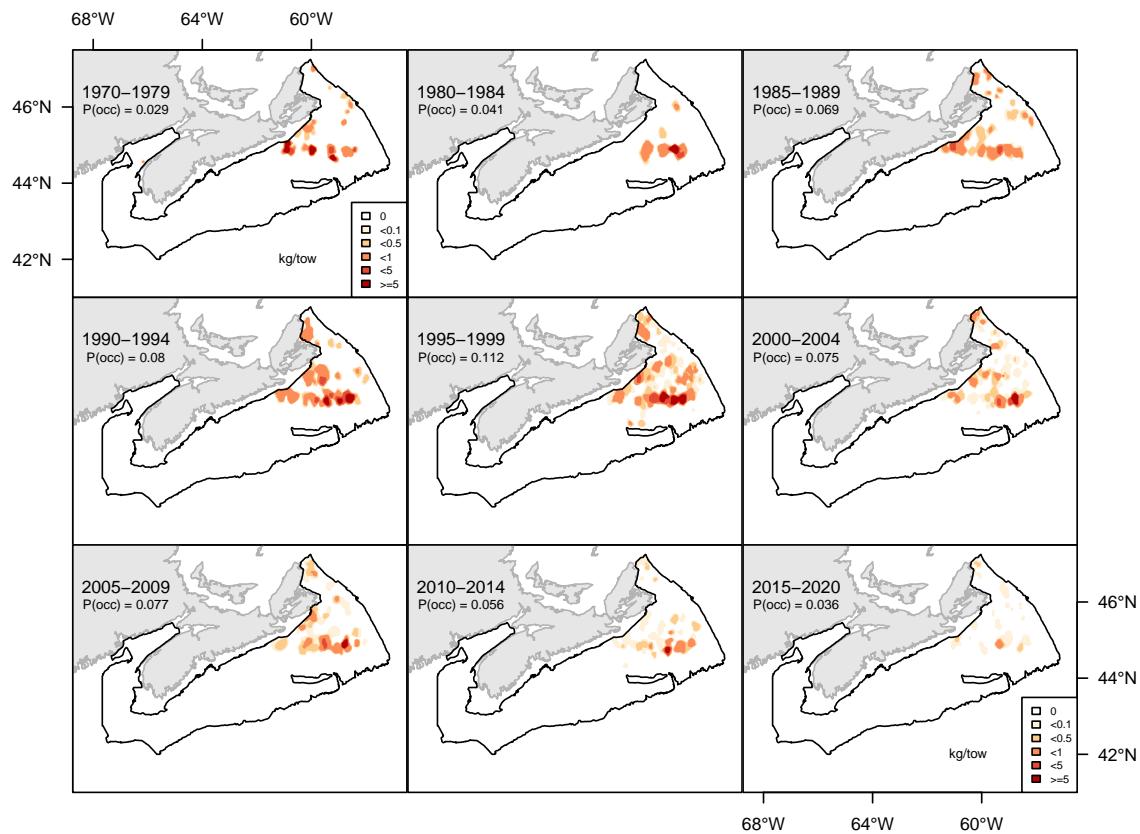


Figure 6.29A. Inverse distance weighted distribution of catch biomass (kg/tow) for Vahl's eelpout.

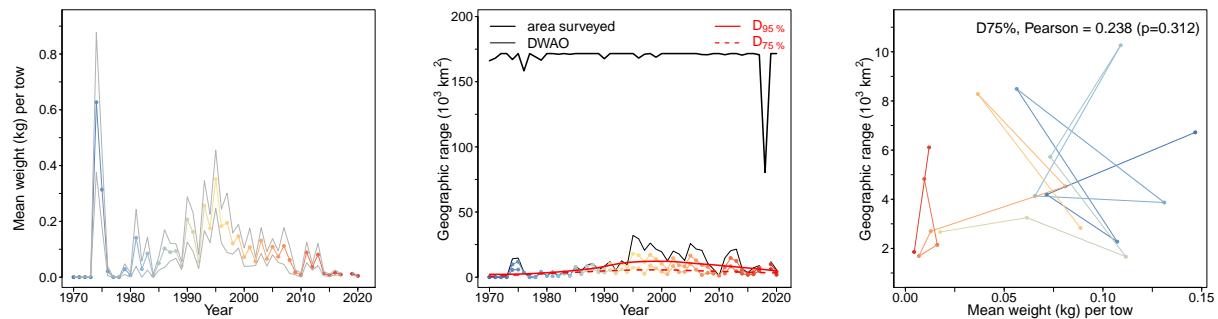


Figure 6.29B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Vahl's eelpout.

6.30 American shad (*Alosa sapidissima*) - species code 61 (category LI)

Scientific name: [Alosa sapidissima](#)

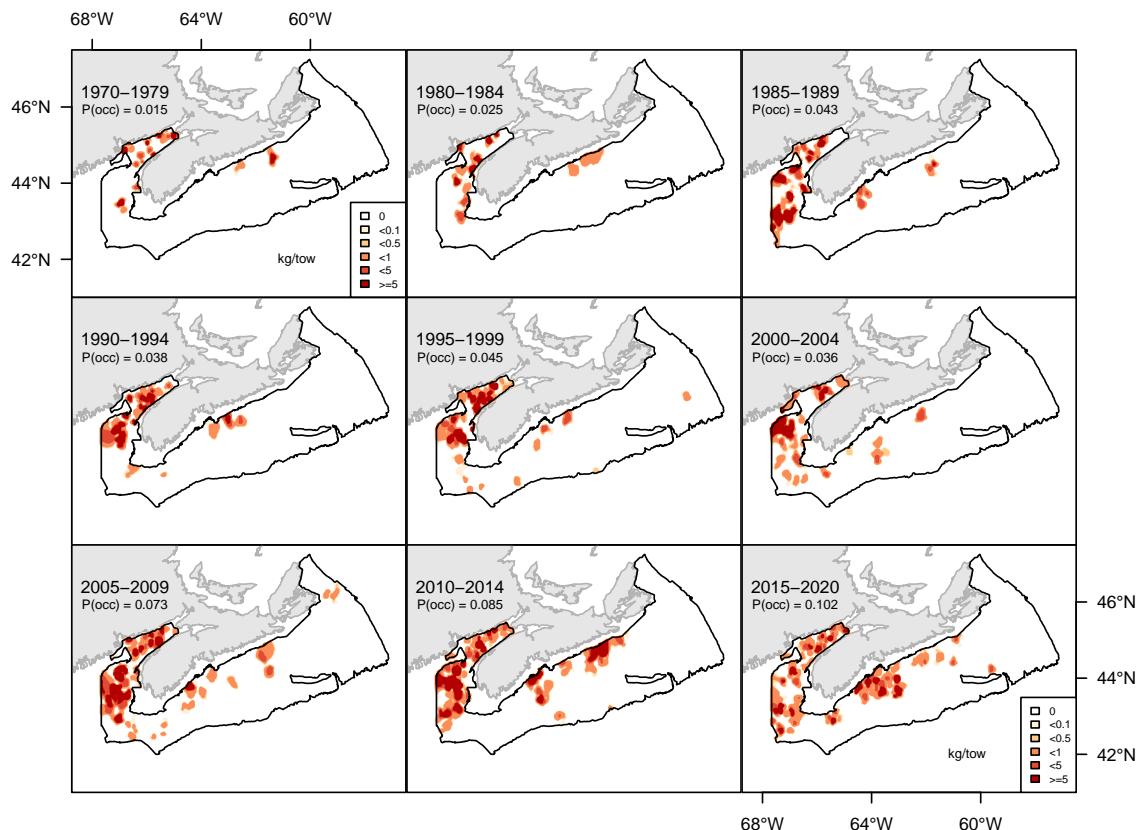


Figure 6.30A. Inverse distance weighted distribution of catch biomass (kg/tow) for American shad.

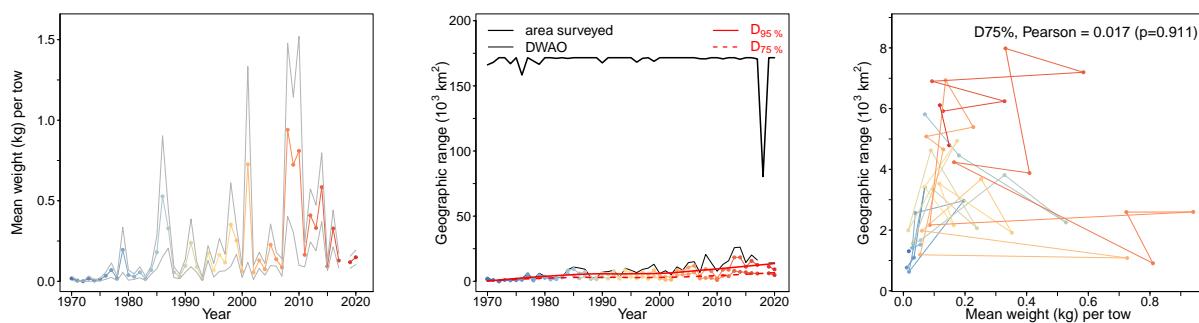


Figure 6.30B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American shad.

6.31 Alewife (Gaspareau) - species code 62 (category LI)

Scientific name: [Alosa pseudoharengus](#)

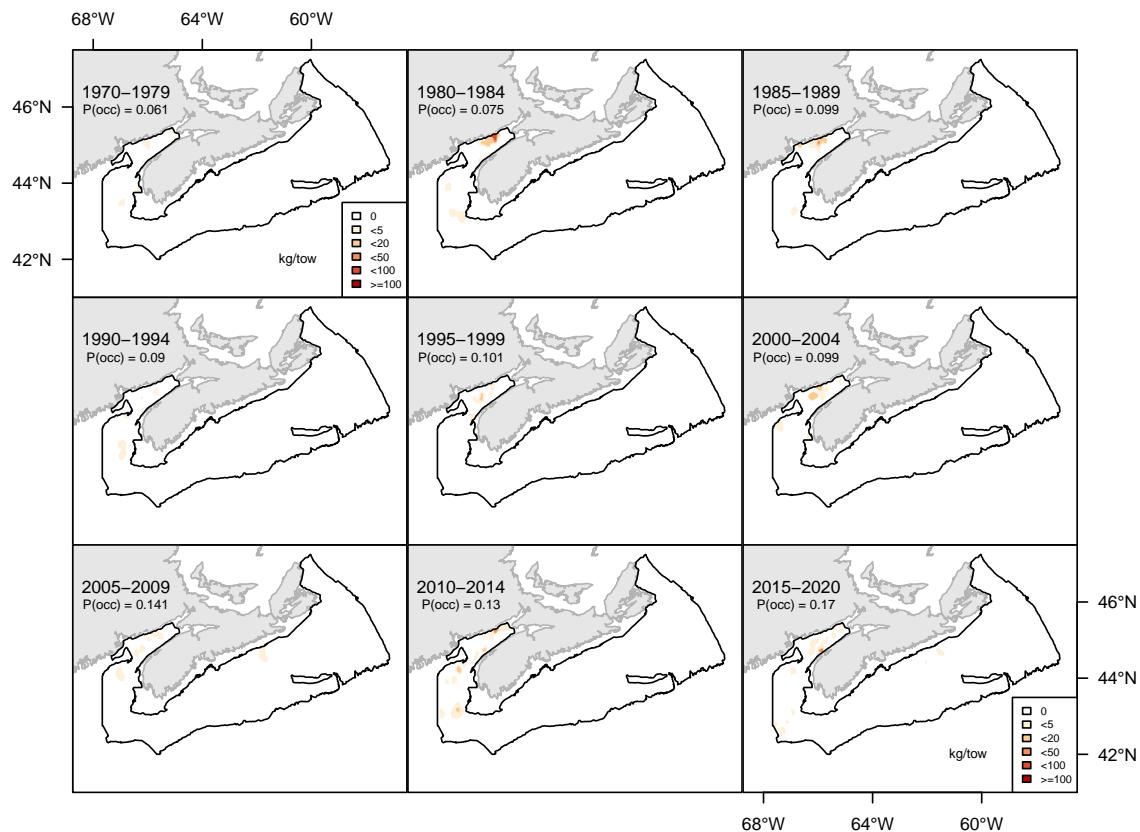


Figure 6.31A. Inverse distance weighted distribution of catch biomass (kg/tow) for Alewife.

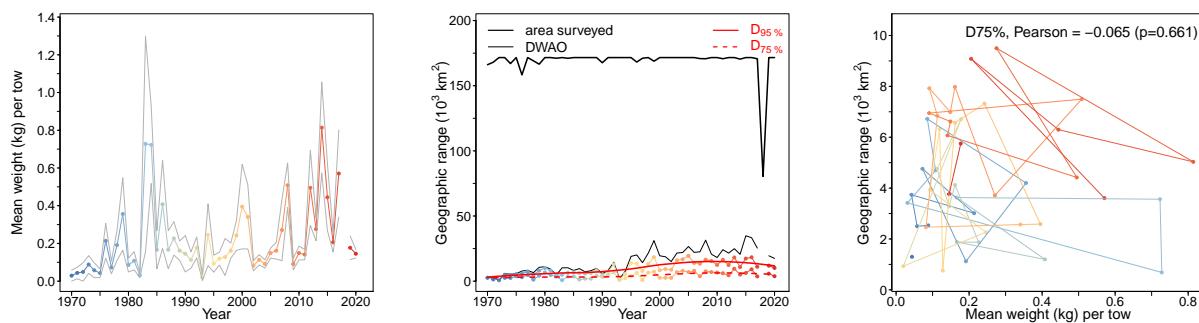


Figure 6.31B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alewife.

6.32 Greater argentine (Grande argentine) - species code 160 (category LI)

Scientific name: [Argentina silus](#)

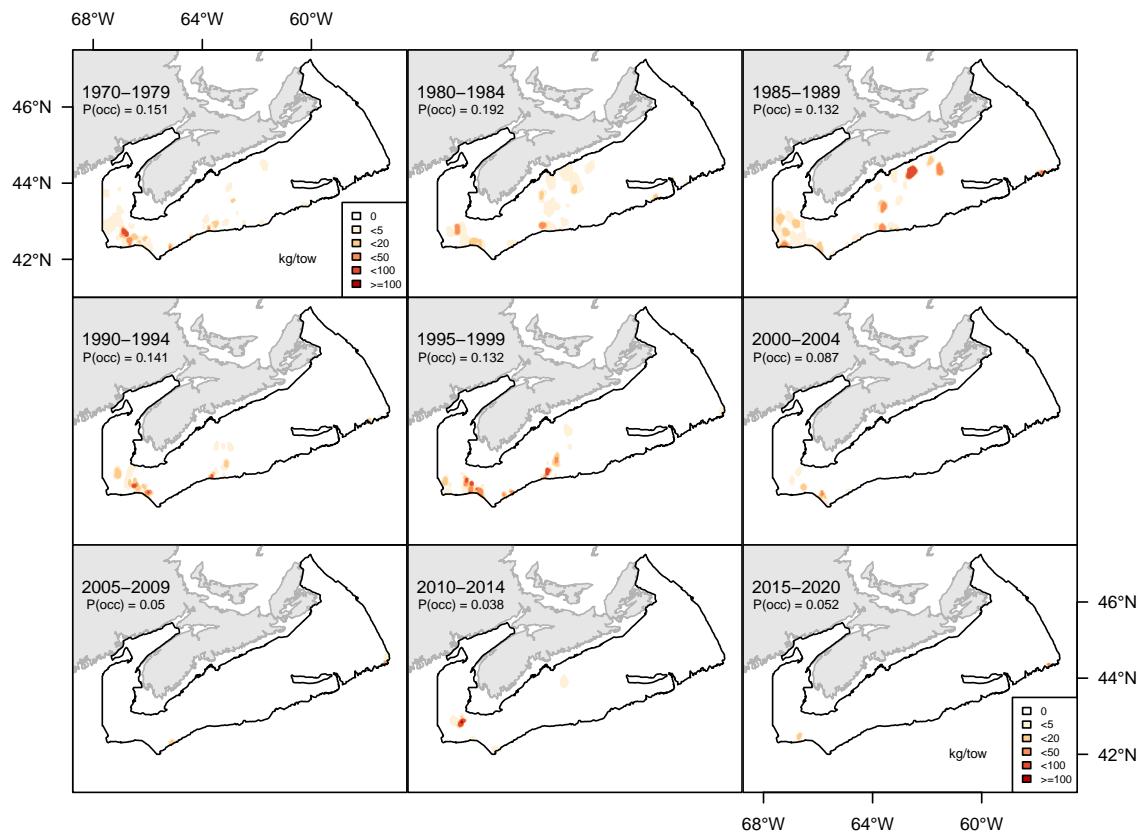


Figure 6.32A. Inverse distance weighted distribution of catch biomass (kg/tow) for Greater argentine.

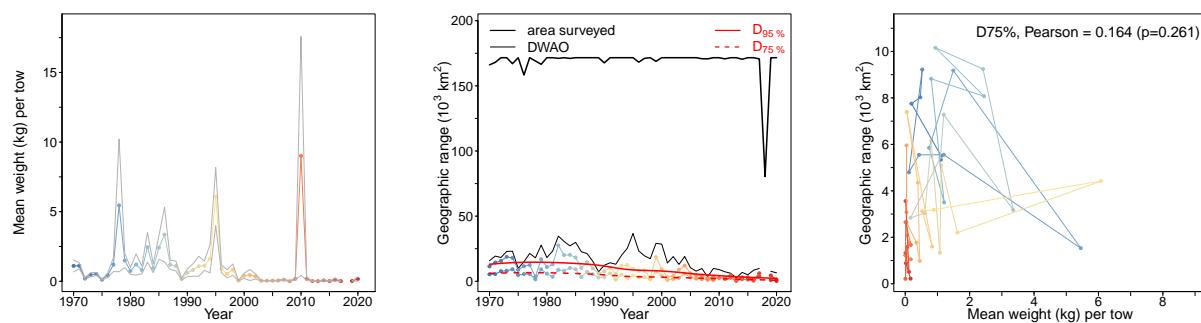


Figure 6.32B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greater argentine.

6.33 Barndoor skate (Grande raie) - species code 200 (category LI)

Scientific name: [Dipturus laevis](#)

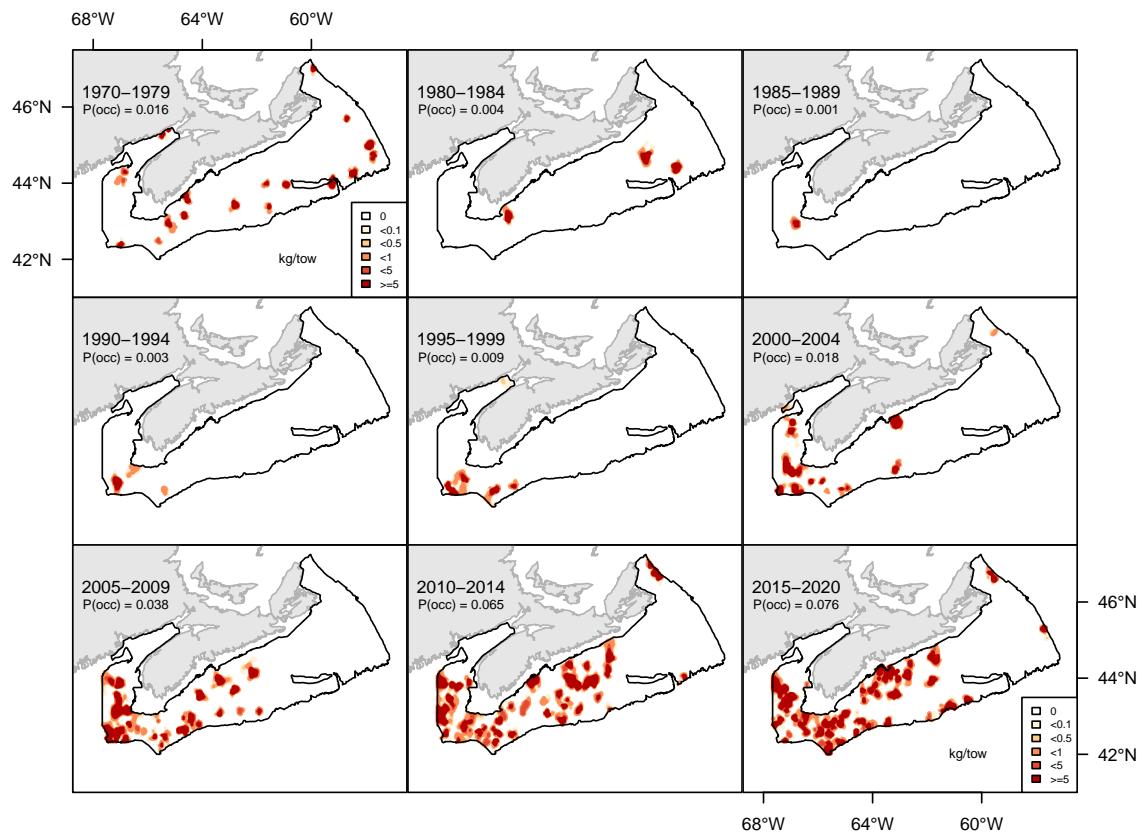


Figure 6.33A. Inverse distance weighted distribution of catch biomass (kg/tow) for Barndoor skate.

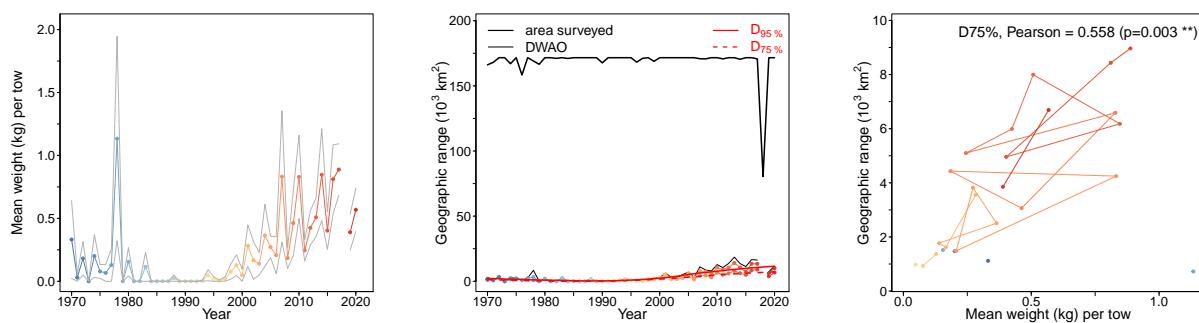


Figure 6.33B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Barndoor skate.

6.34 Little skate (Raie hérisson) - species code 203 (category LI)

Scientific name: [Leucoraja erinacea](#)

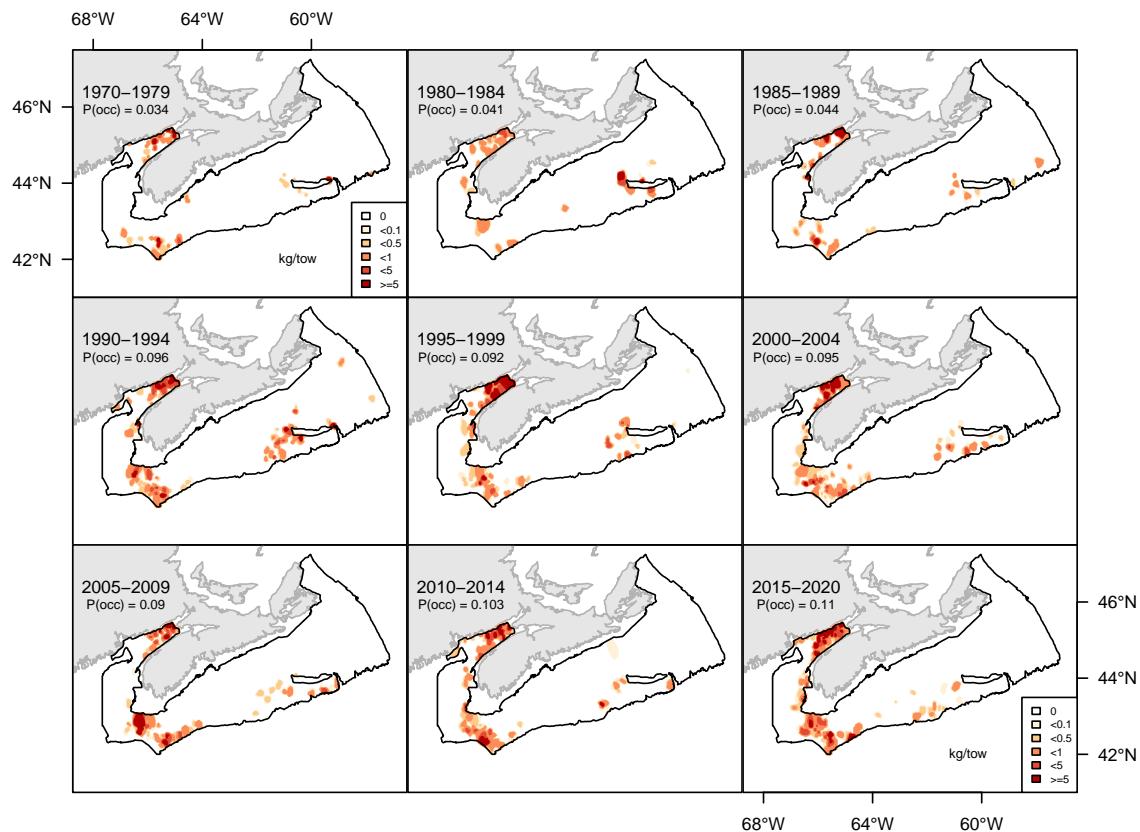


Figure 6.34A. Inverse distance weighted distribution of catch biomass (kg/tow) for Little skate.

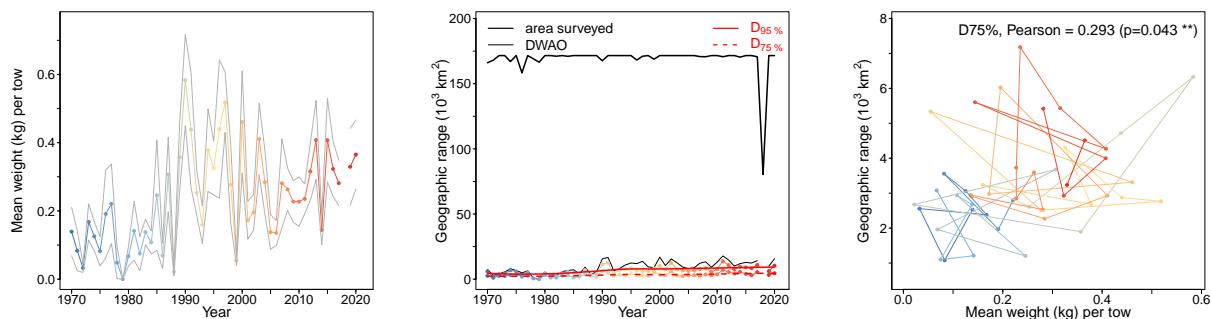


Figure 6.34B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Little skate.

6.35 Winter skate (Raie tachetée) - species code 204 (category LI)

Scientific name: [Leucoraja ocellata](#)

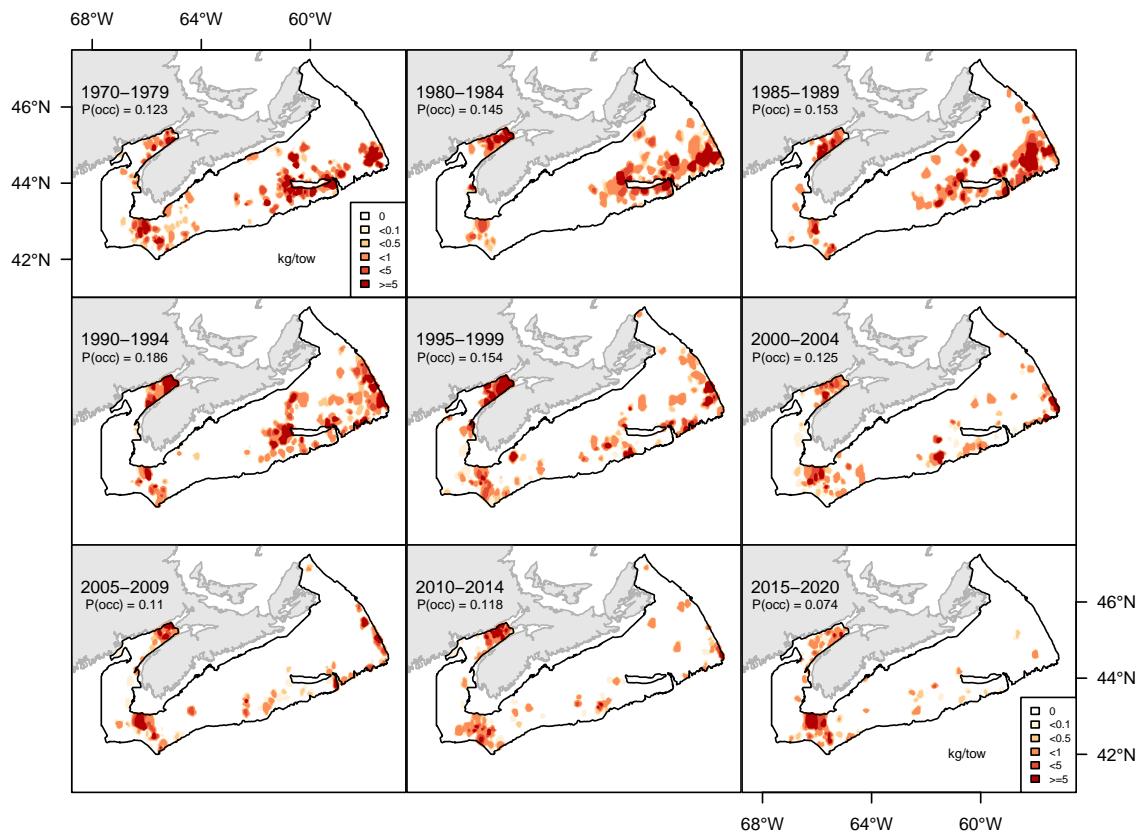


Figure 6.35A. Inverse distance weighted distribution of catch biomass (kg/tow) for Winter skate.

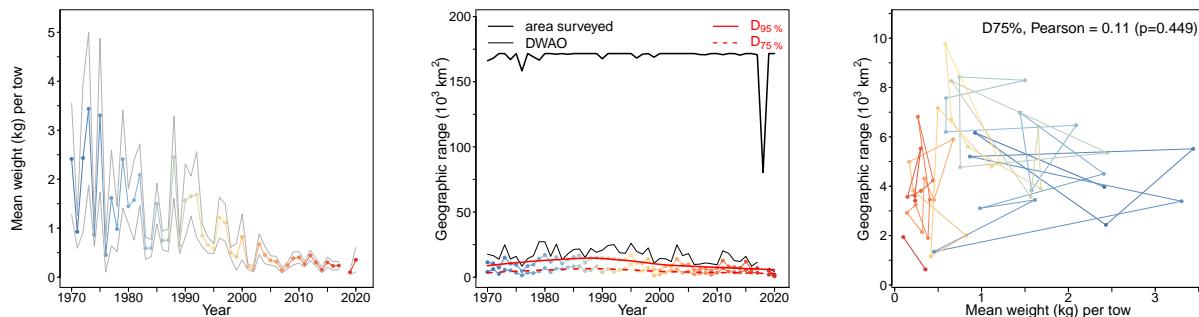


Figure 6.35B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Winter skate.

6.36 Atlantic mackerel (*Maquereau commun*) - species code 70 (category LI)

Scientific name: [Scomber scombrus](#)

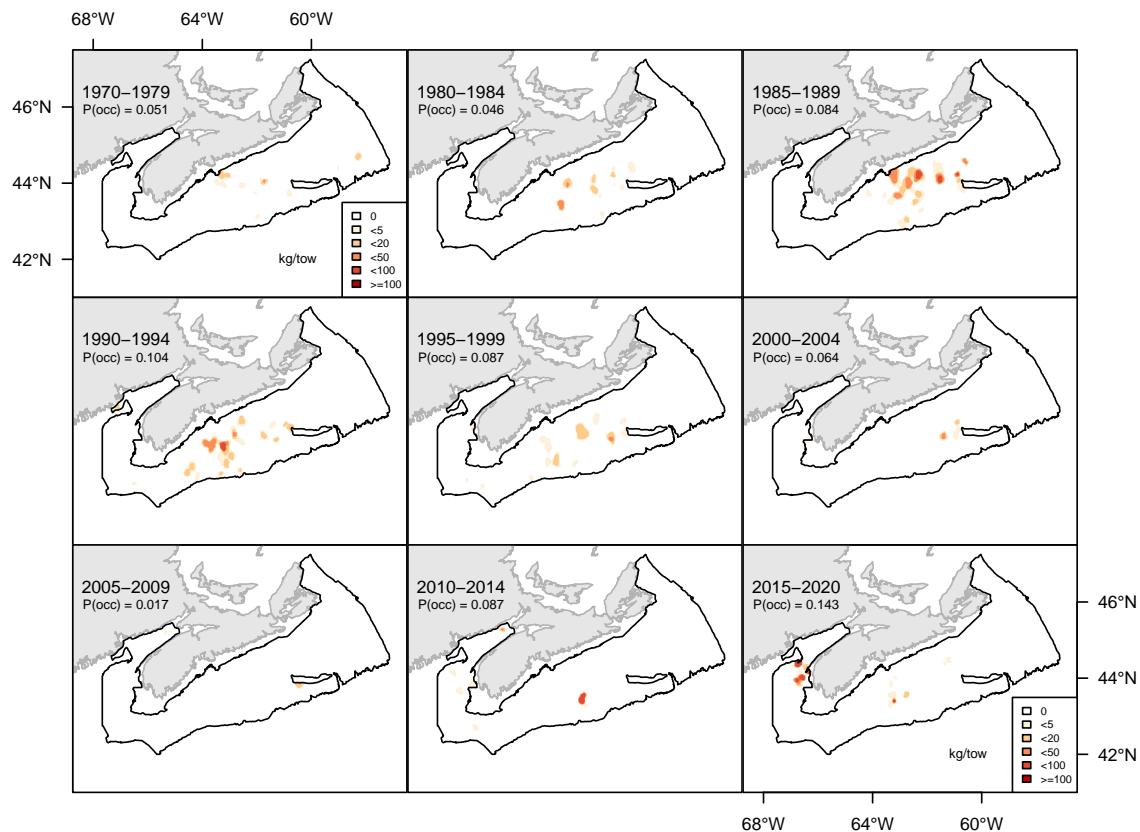


Figure 6.36A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic mackerel.

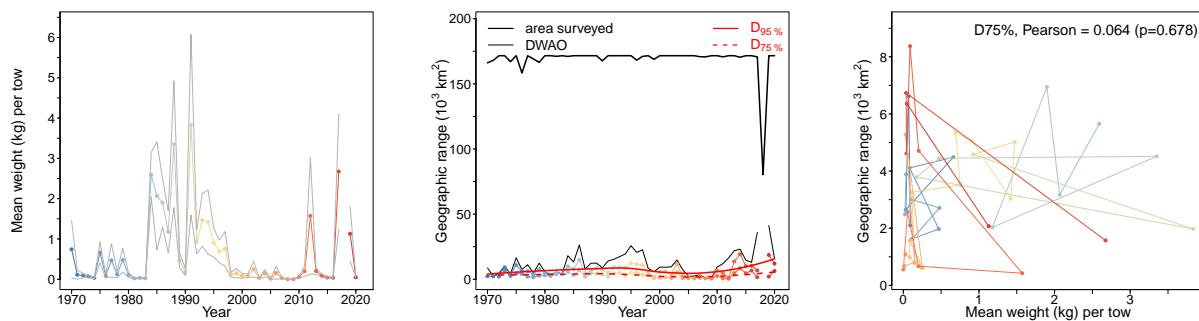


Figure 6.36B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic mackerel.

6.37 Fourbeard rockling (Motelle à 4 barbillons) - species code 114 (category LIn)

Scientific name: [Enchelyopus cimbrius](#)

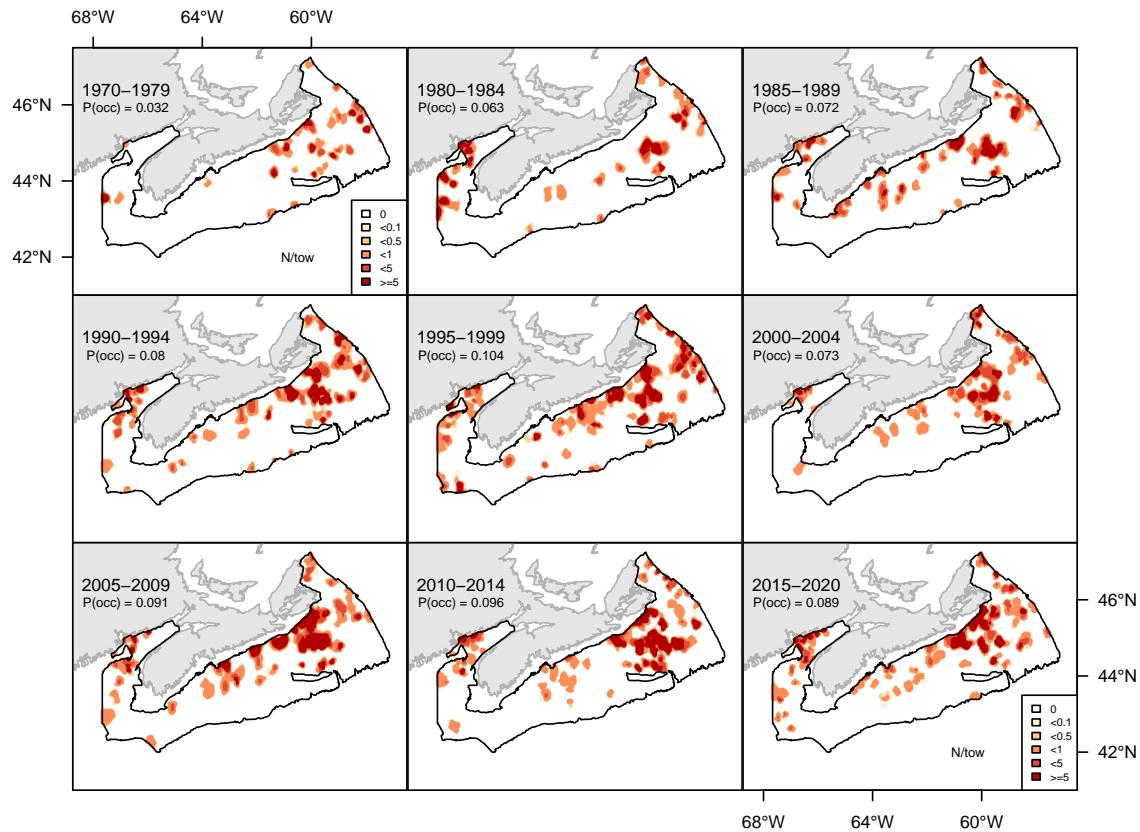


Figure 6.37A. Inverse distance weighted distribution of catch abundance (N/tow) for Fourbeard rockling.

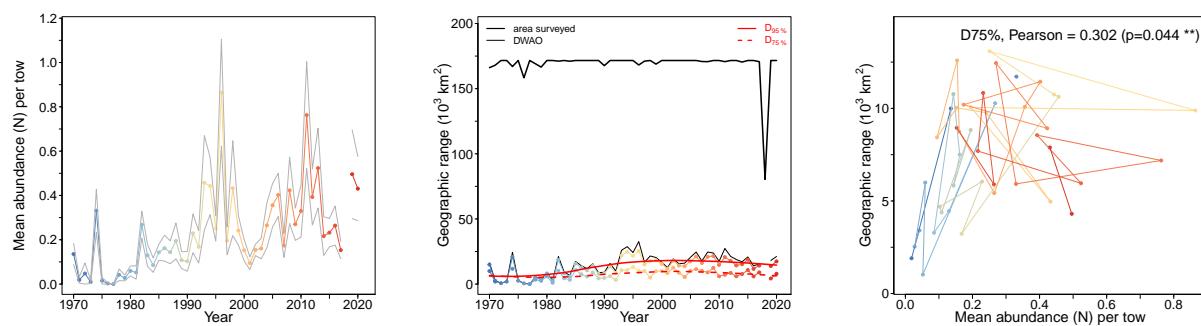


Figure 6.37B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Fourbeard rockling.

6.38 Greenland halibut (Flétan du Groënland) - species code 31 (category LIn)

Scientific name: [Reinhardtius hippoglossoides](#)

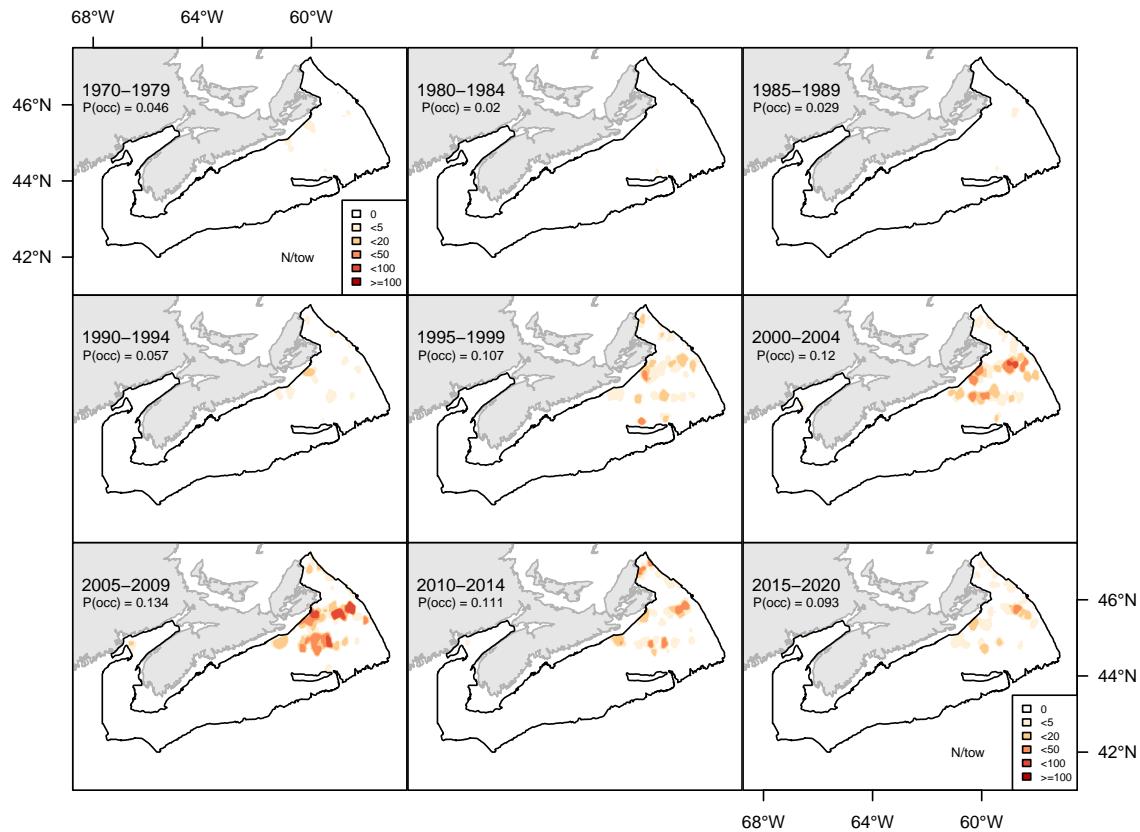


Figure 6.38A. Inverse distance weighted distribution of catch abundance (N/tow) for Greenland halibut.

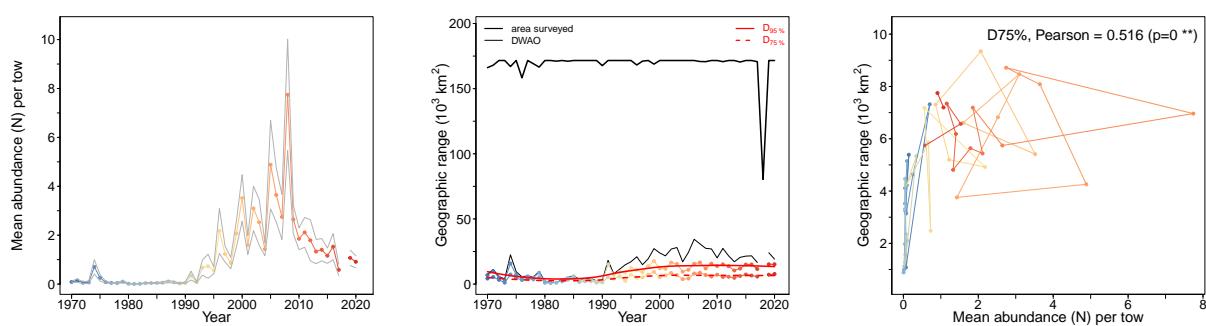


Figure 6.38B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Greenland halibut.

6.39 Gulf Stream flounder (Plie du Gulf Stream) - species code 44 (category LIn)

Scientific name: [Citharichthys arctifrons](#)

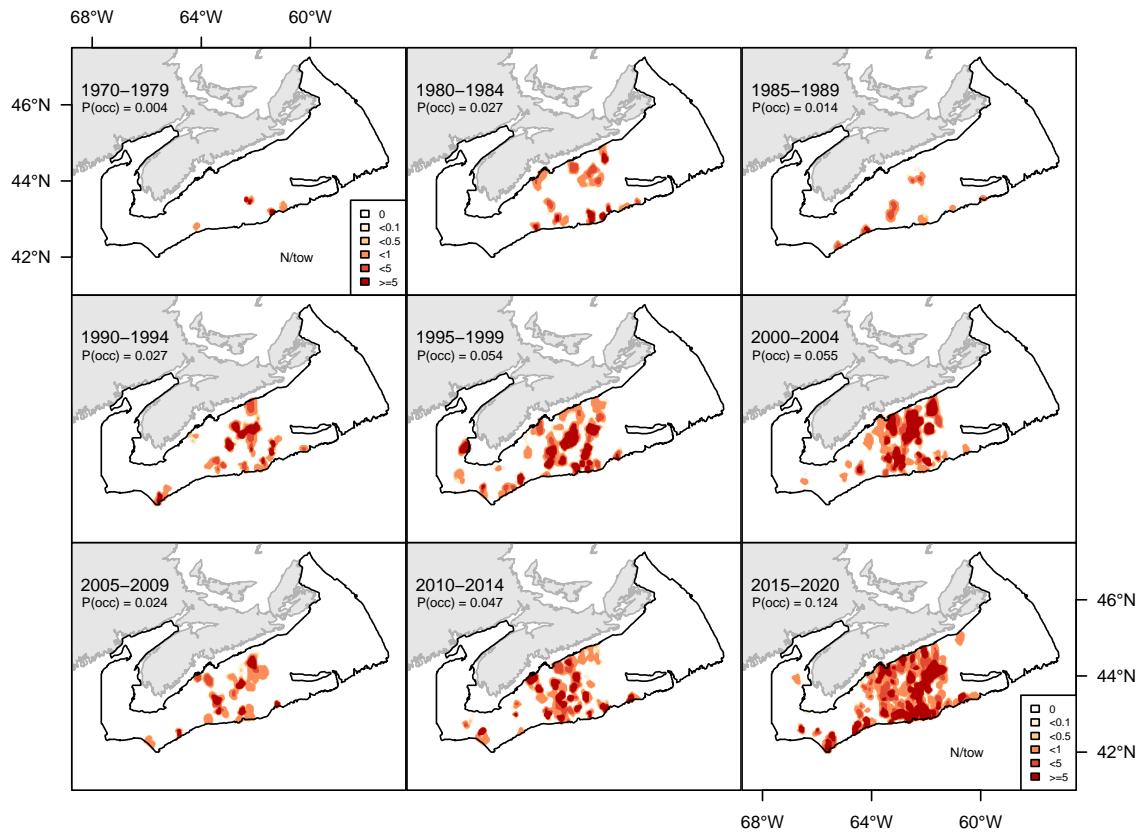


Figure 6.39A. Inverse distance weighted distribution of catch abundance (N/tow) for Gulf Stream flounder.

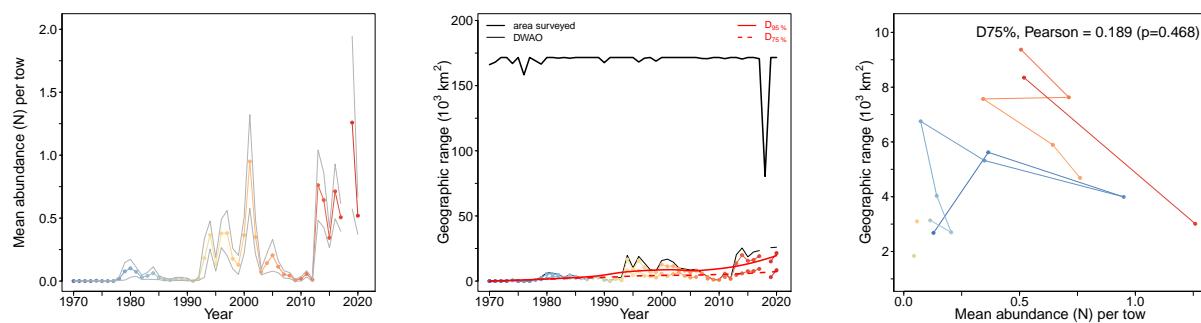


Figure 6.39B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Gulf Stream flounder.

6.40 Blackbelly rosefish (Sébaste chèvre) - species code 123 (category LIn)

Scientific name: [Helicolenus dactylopterus](#)

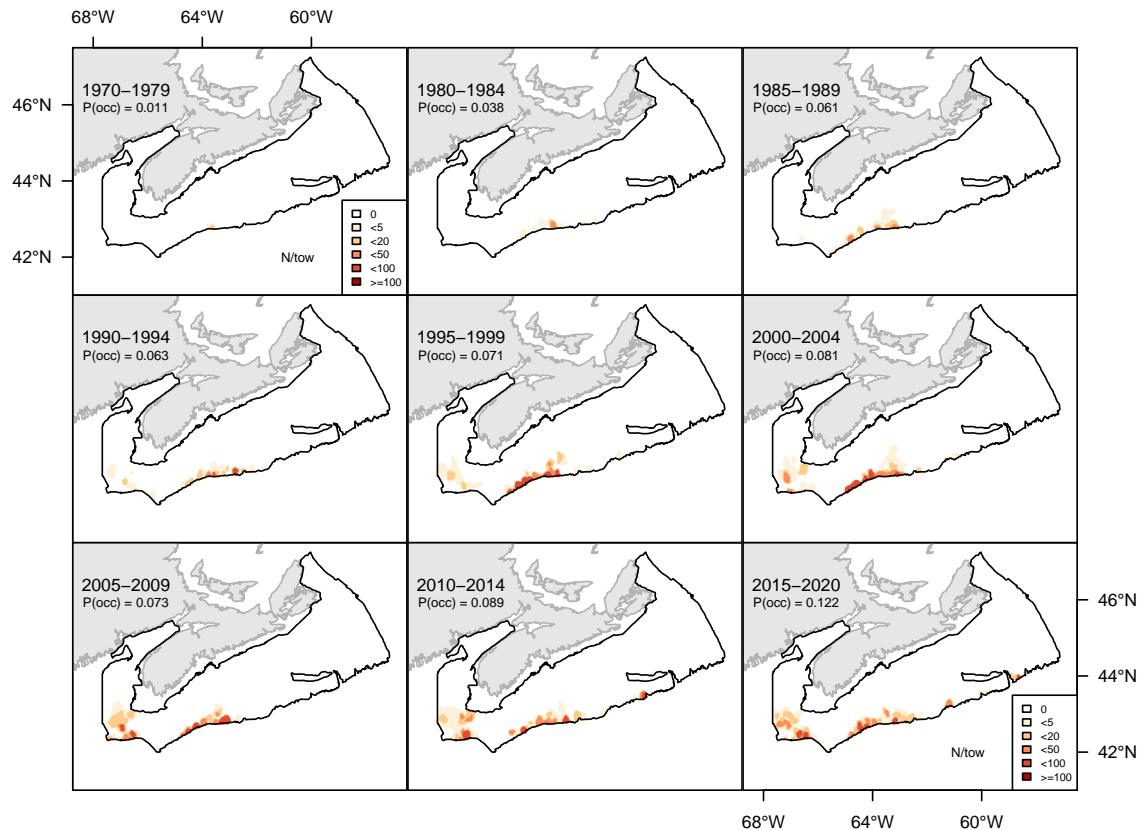


Figure 6.40A. Inverse distance weighted distribution of catch abundance (N/tow) for Blackbelly rosefish.

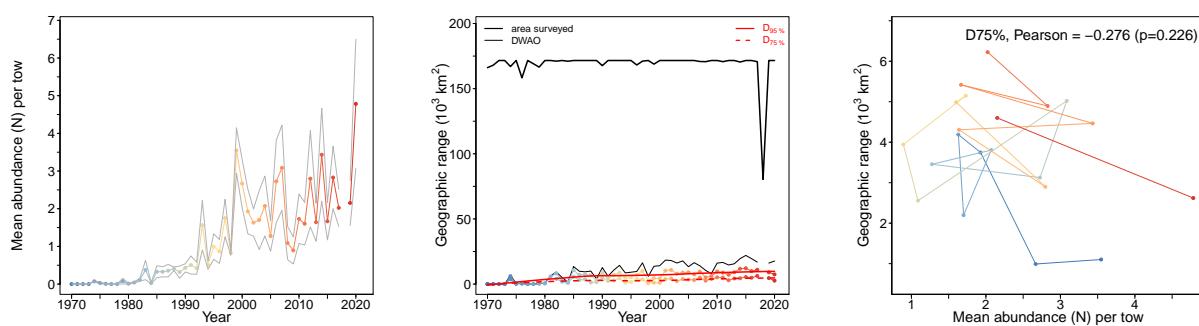


Figure 6.40B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Blackbelly rosefish.

6.41 Arctic hookear sculpin (*Hameçon neigeux*) - species code 306 (category LIn)

Scientific name: [Arctediellus uncinatus](#)

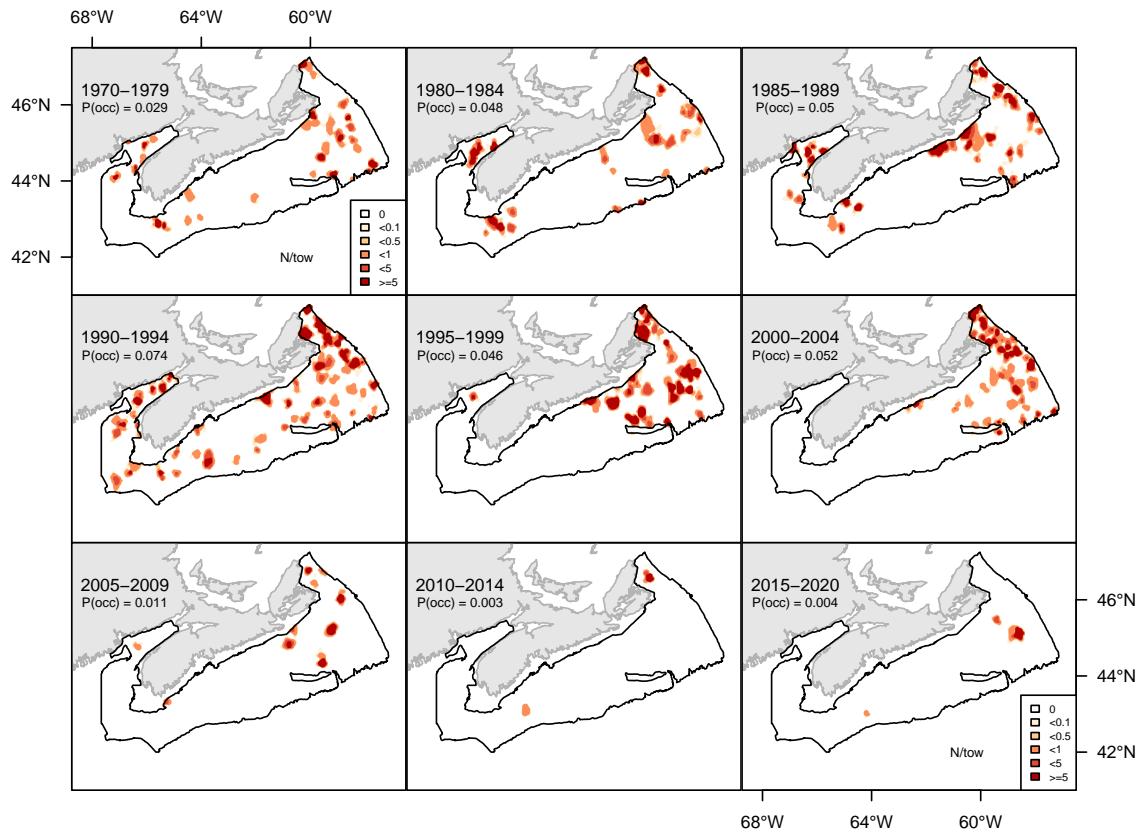


Figure 6.41A. Inverse distance weighted distribution of catch abundance (N/tow) for Arctic hookear sculpin.

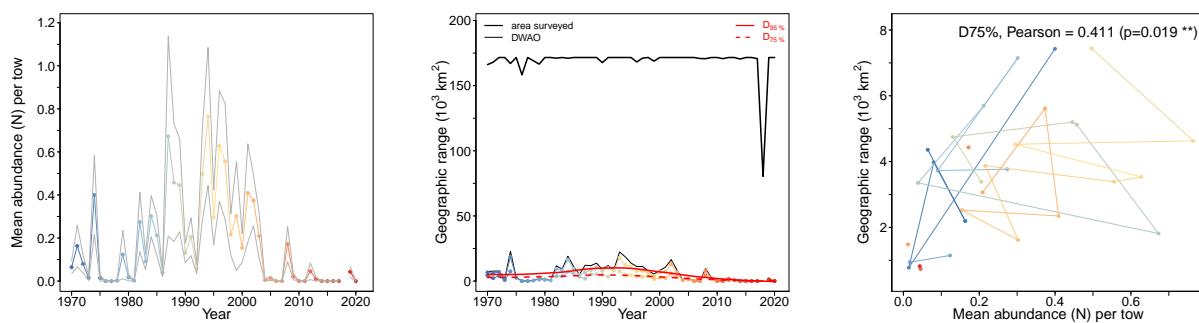


Figure 6.41B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic hookear sculpin.

6.42 Alligatorfish (Poisson-alligator atlantique) - species code 340 (category LIn)

Scientific name: [Aspidophoroides monopterygius](#)

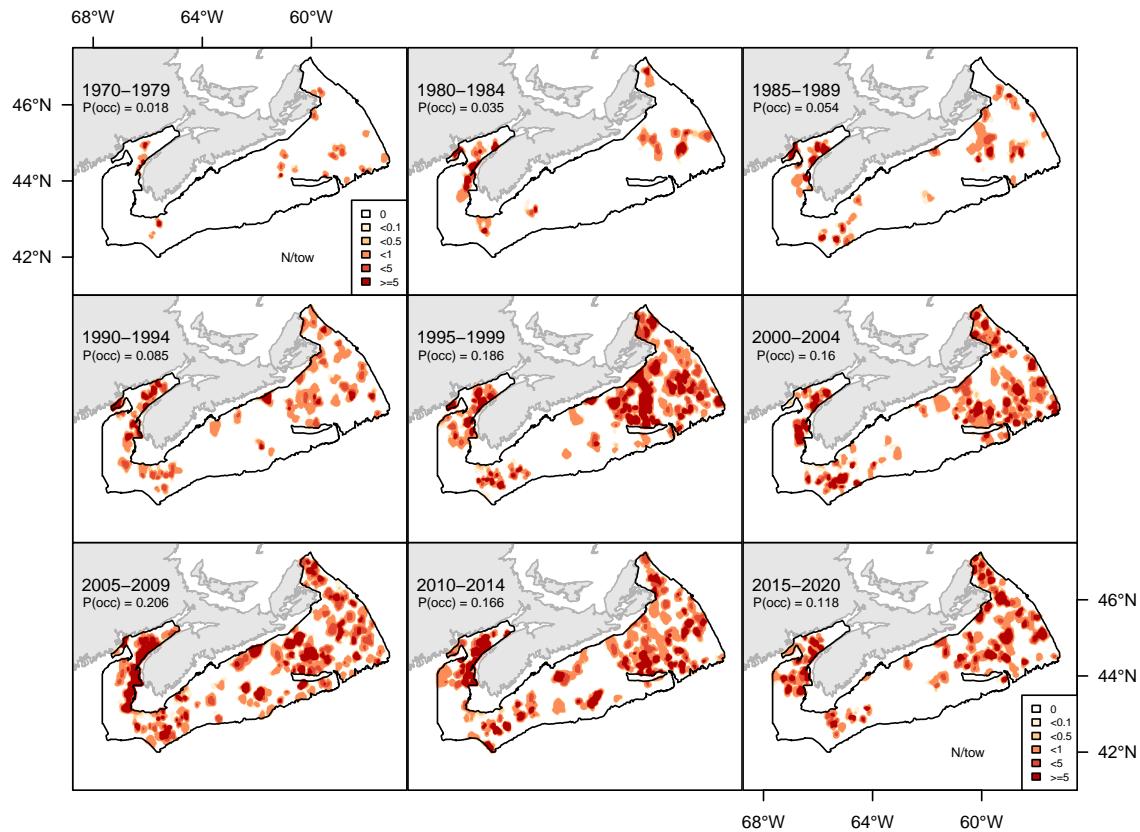


Figure 6.42A. Inverse distance weighted distribution of catch abundance (N/tow) for Alligatorfish.

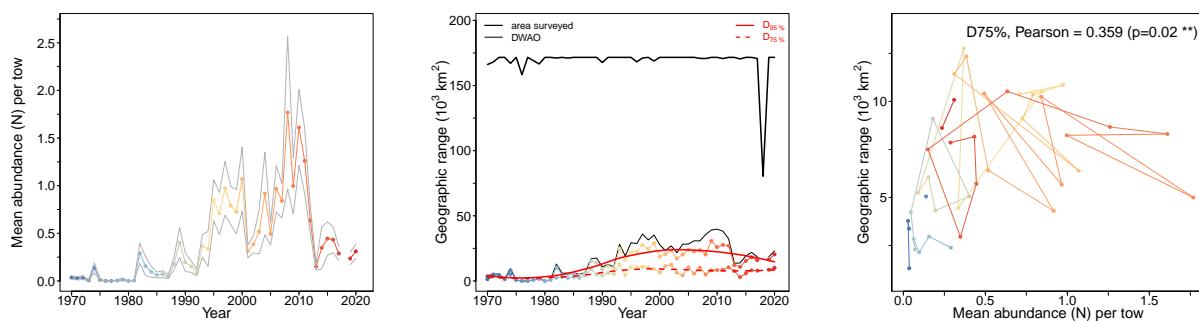


Figure 6.42B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Alligatorfish.

6.43 Atlantic poacher (*Agone atlantique*) - species code 350 (category LIn)

Scientific name: [Leptagonus decagonus](#)

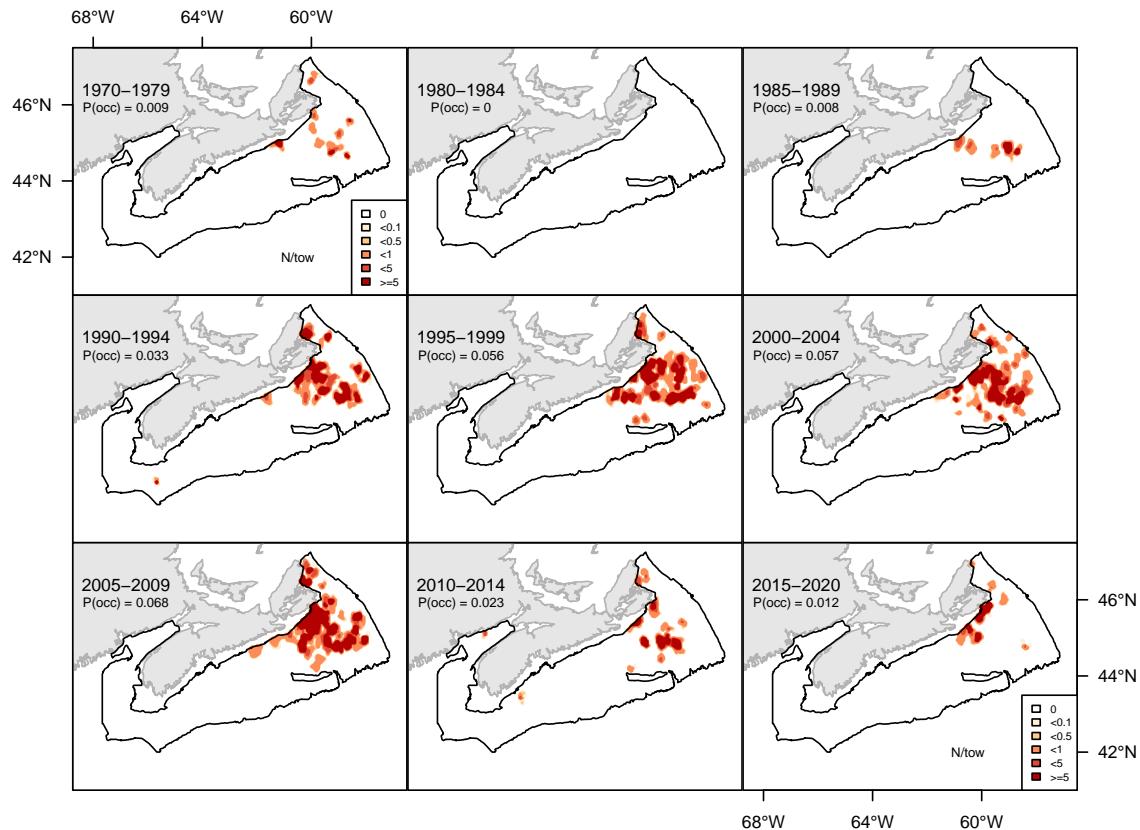


Figure 6.43A. Inverse distance weighted distribution of catch abundance (N/tow) for Atlantic poacher.

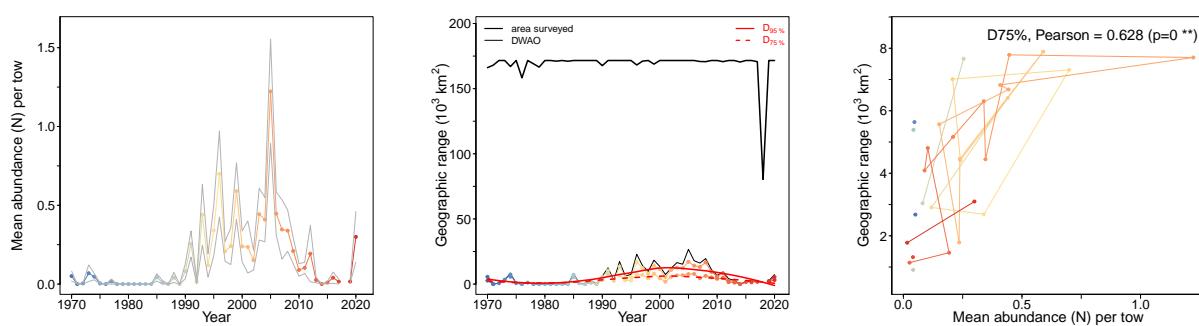


Figure 6.43B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic poacher.

6.44 Atl. spiny lumpsucker (Petite poule de mer atl.) - species code 502 (category LIn)

Scientific name: [Eumicrotremus spinosus](#)

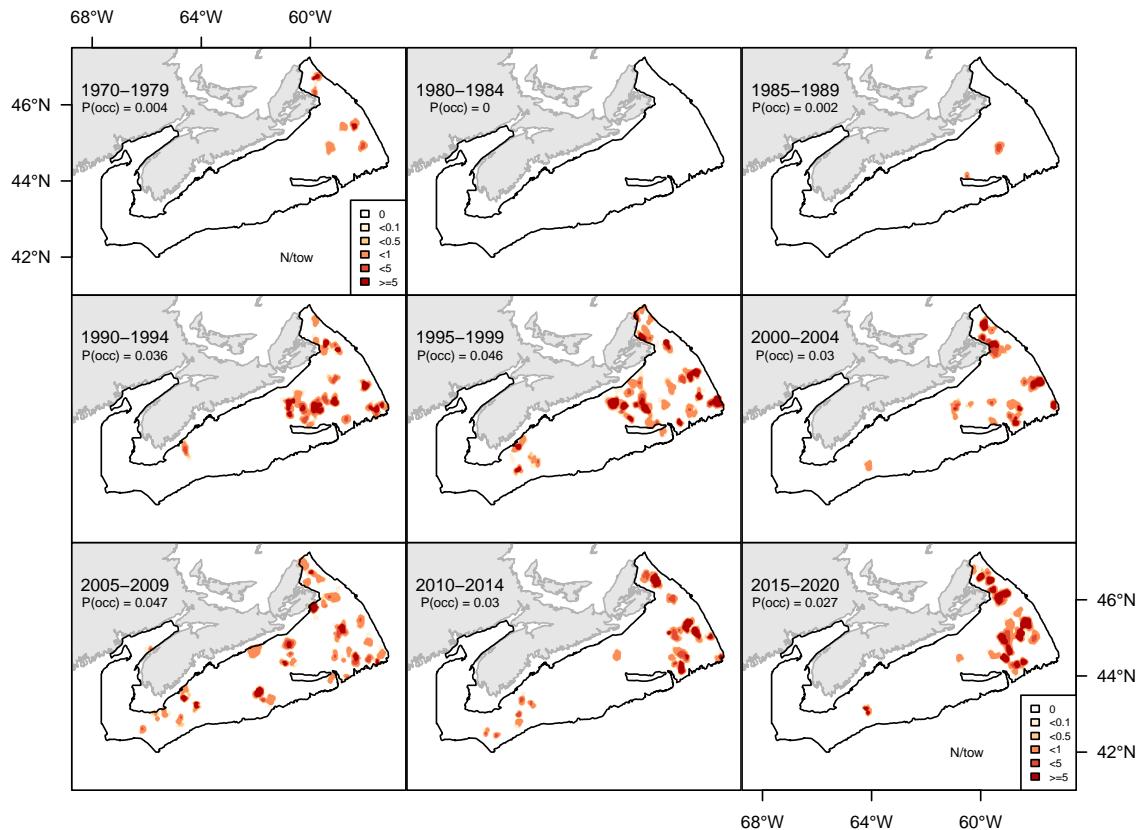


Figure 6.44A. Inverse distance weighted distribution of catch abundance (N/tow) for Atl. spiny lumpsucker.

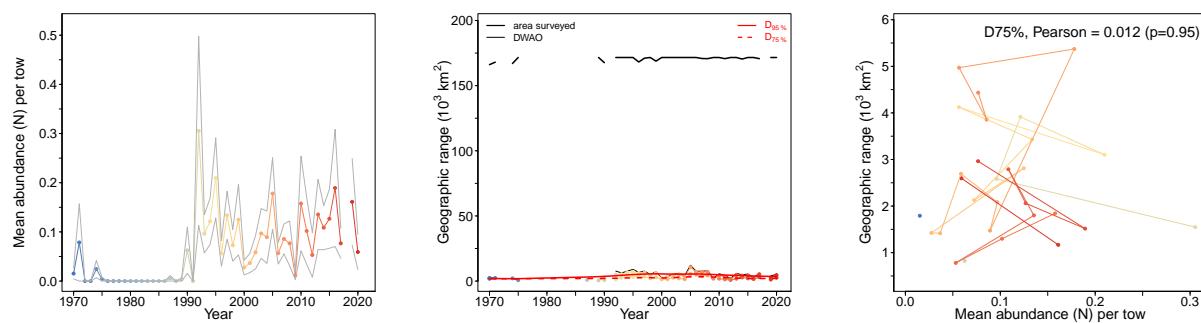


Figure 6.44B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atl. spiny lumpsucker.

6.45 Sand lance (Lançon) - species code 610 (category LIn)

Scientific name: [Ammodytes dubius](#)

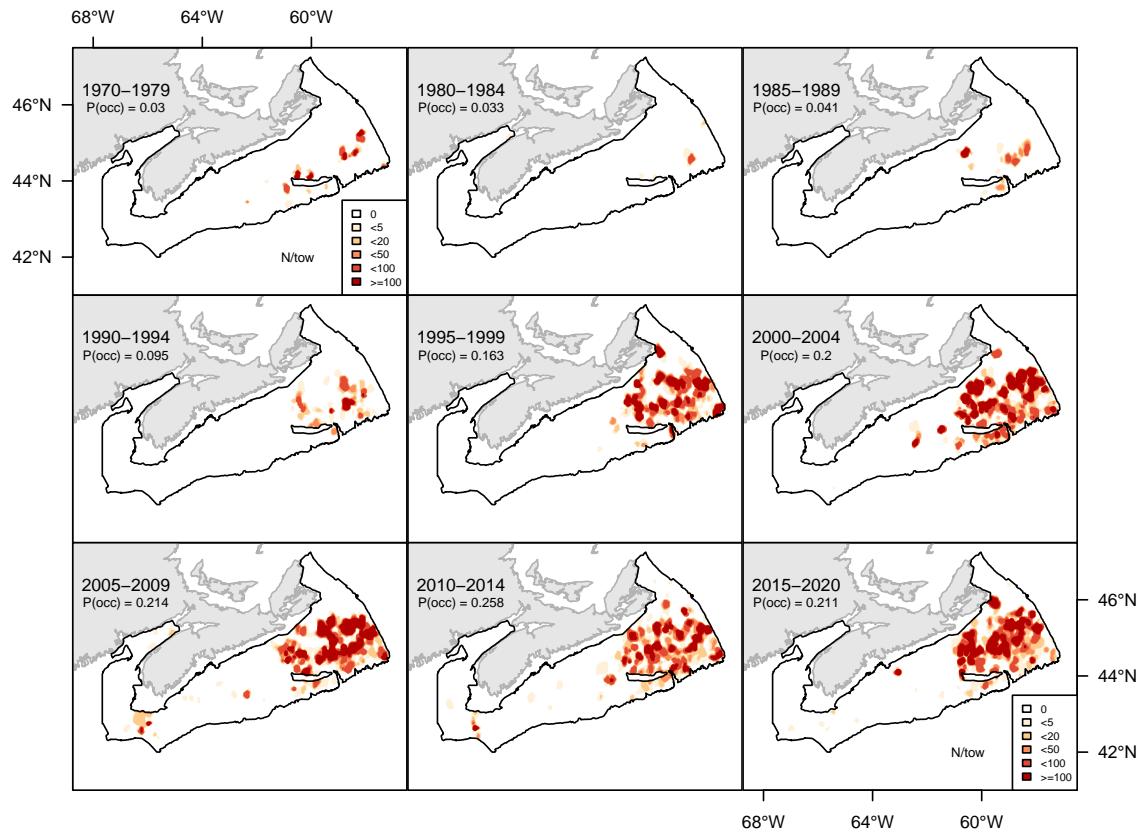


Figure 6.45A. Inverse distance weighted distribution of catch abundance (N/tow) for Sand lance.

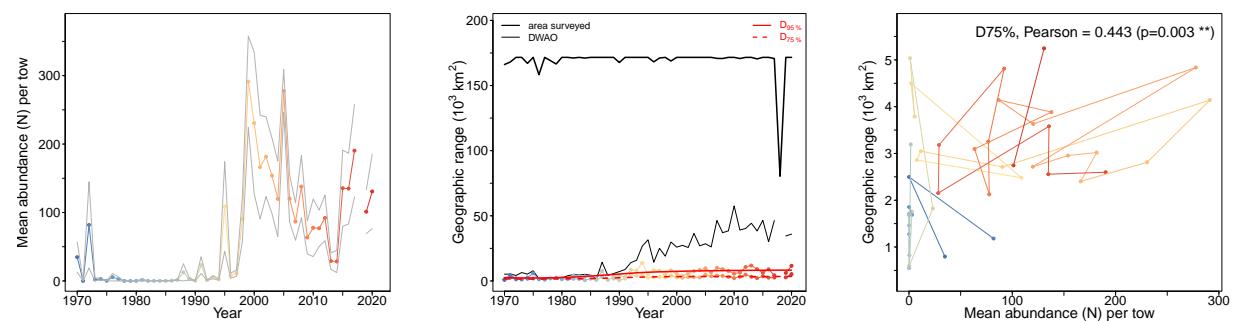


Figure 6.45B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Sand lance.

6.46 Snakeblenny (Lompénie-serpent) - species code 622 (category LIn)

Scientific name: [Lumpenus lampretaeformis](#)

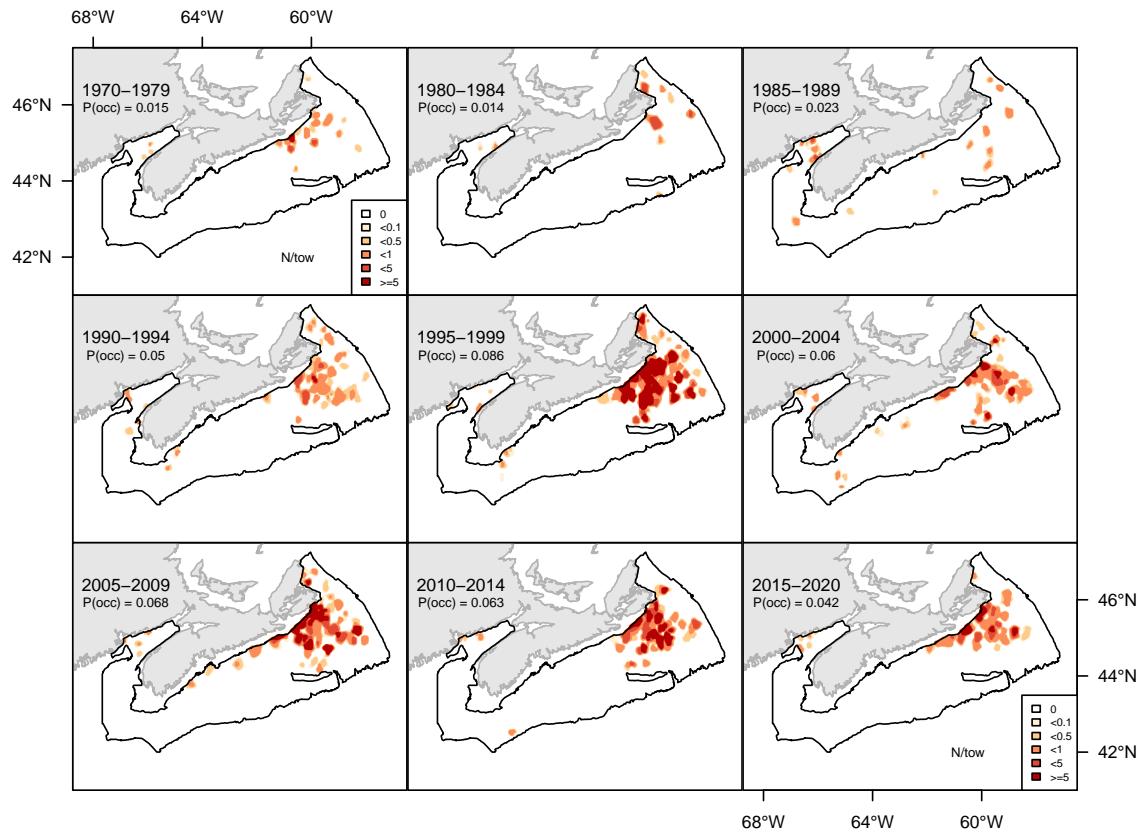


Figure 6.46A. Inverse distance weighted distribution of catch abundance (N/tow) for Snakeblenny.

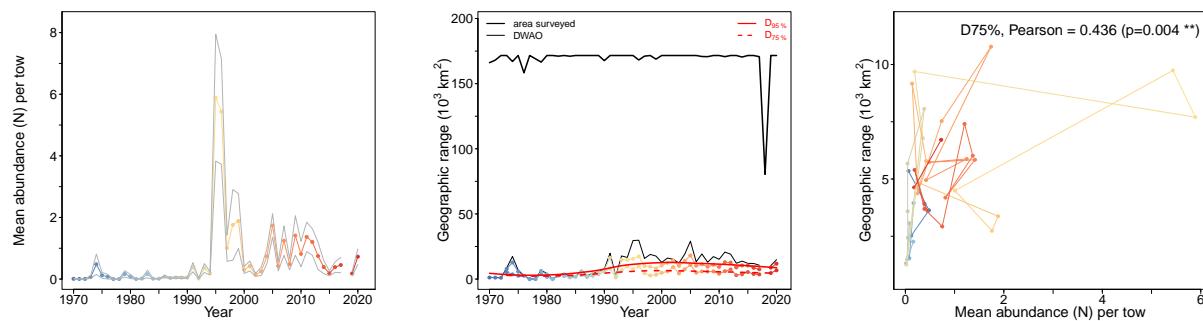


Figure 6.46B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Snakeblenny.

6.47 Daubed shanny (Lompénie tachetée) - species code 623 (category LIn)

Scientific name: [Leptoclinus maculatus](#)

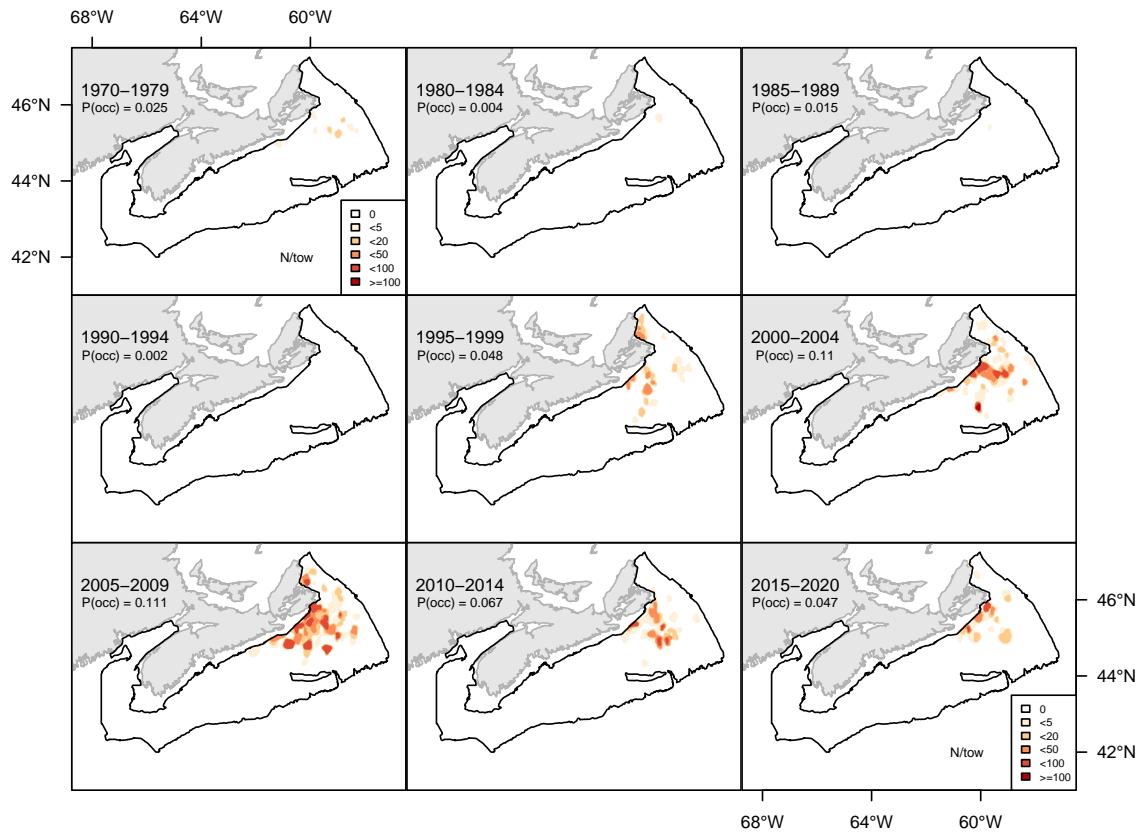


Figure 6.47A. Inverse distance weighted distribution of catch abundance (N/tow) for Daubed shanny.

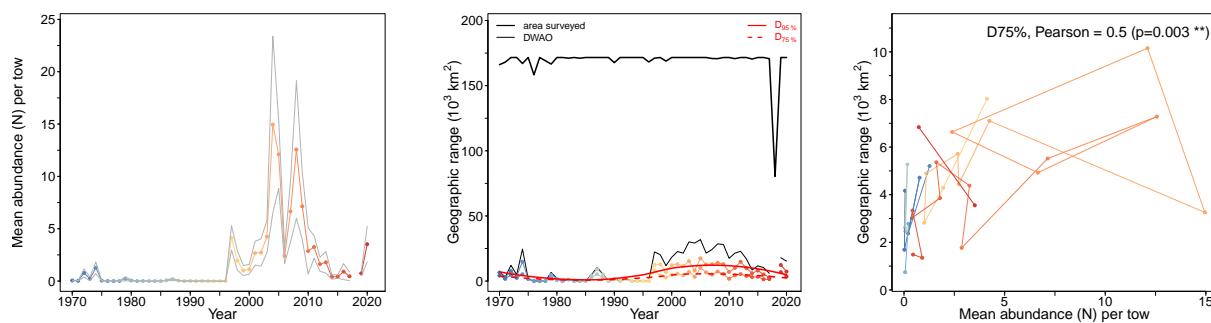


Figure 6.47B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Daubed shanny.

6.48 Atlantic butterfish (Stromatée à fossettes) - species code 701 (category LIn)

Scientific name: [Peprilus triacanthus](#)

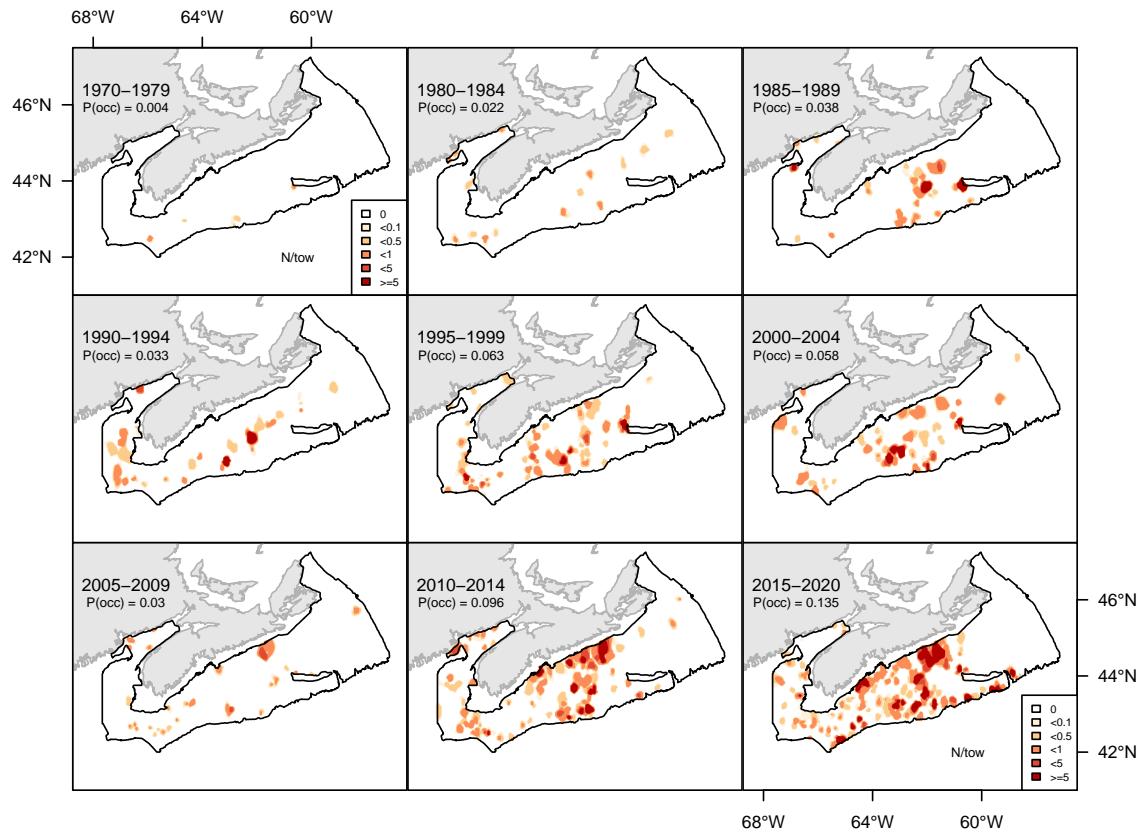


Figure 6.48A. Inverse distance weighted distribution of catch abundance (N/tow) for Atlantic butterfish.

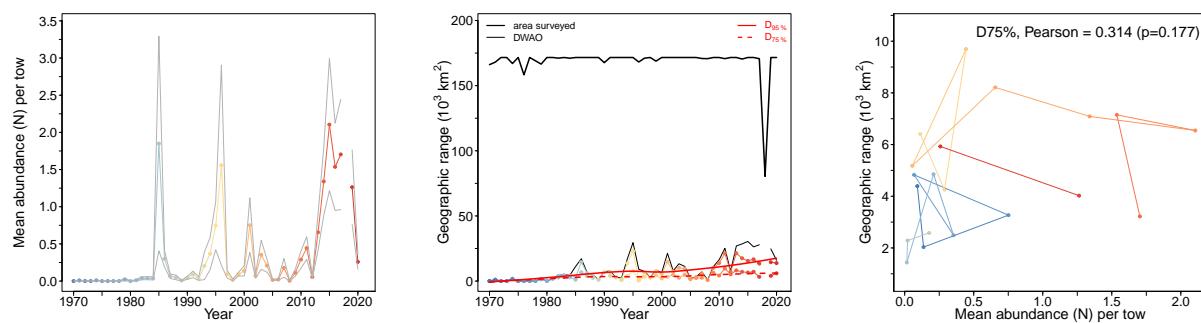


Figure 6.48B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic butterfish.

6.49 Atlantic hookear sculpin (*Hameçon atlantique*) - species code 880 (category LIn)

Scientific name: [Arctediellus atlanticus](#)

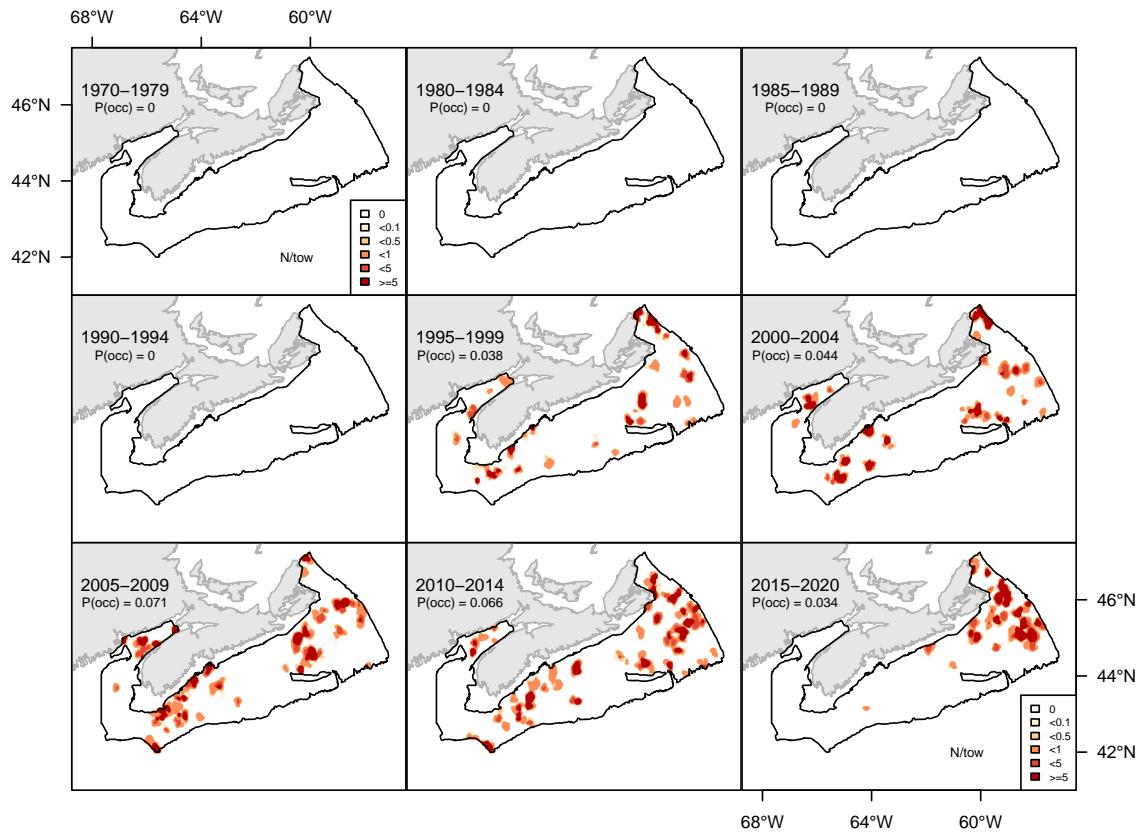


Figure 6.49A. Inverse distance weighted distribution of catch abundance (N/tow) for Atlantic hookear sculpin.

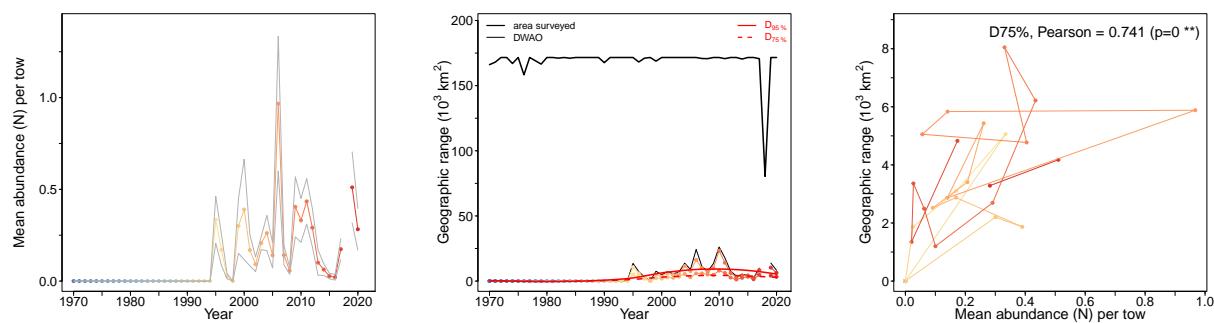


Figure 6.49B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic hookear sculpin.

6.50 Capelin (Capelan) - species code 64 (category LIn)

Scientific name: [Mallotus villosus](#)

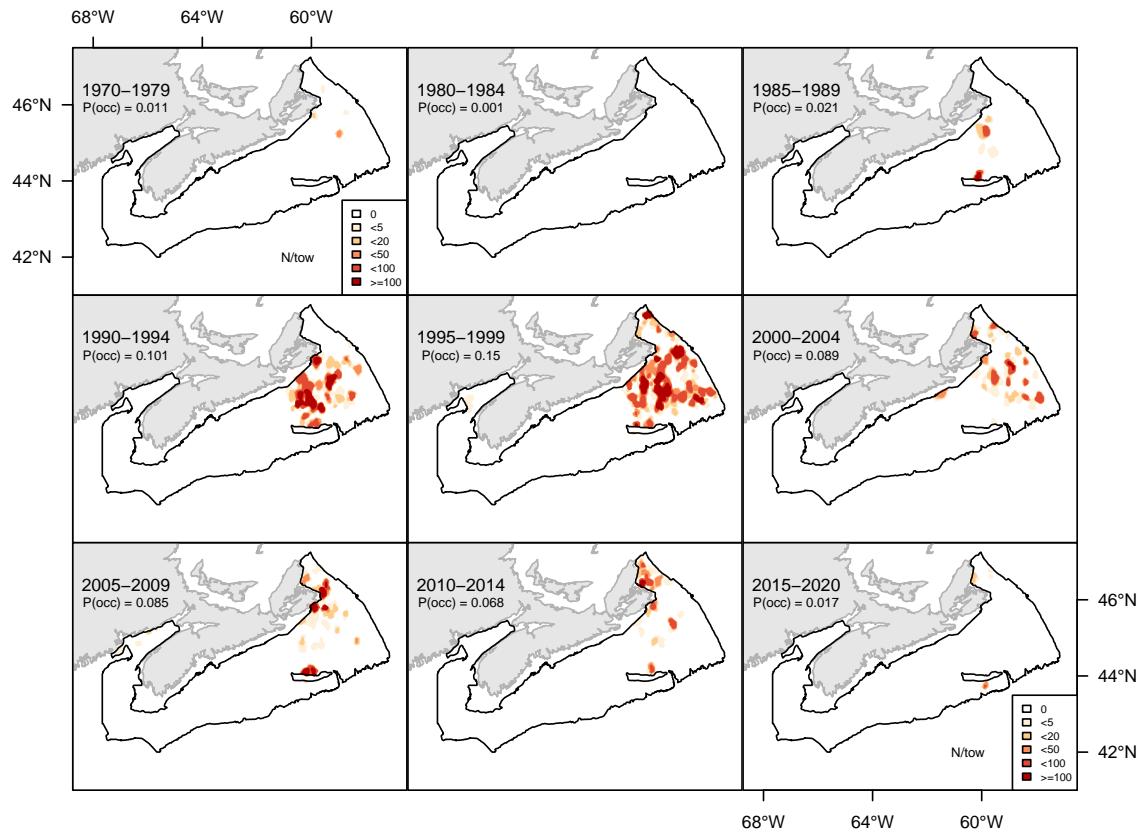


Figure 6.50A. Inverse distance weighted distribution of catch abundance (N/tow) for Capelin.

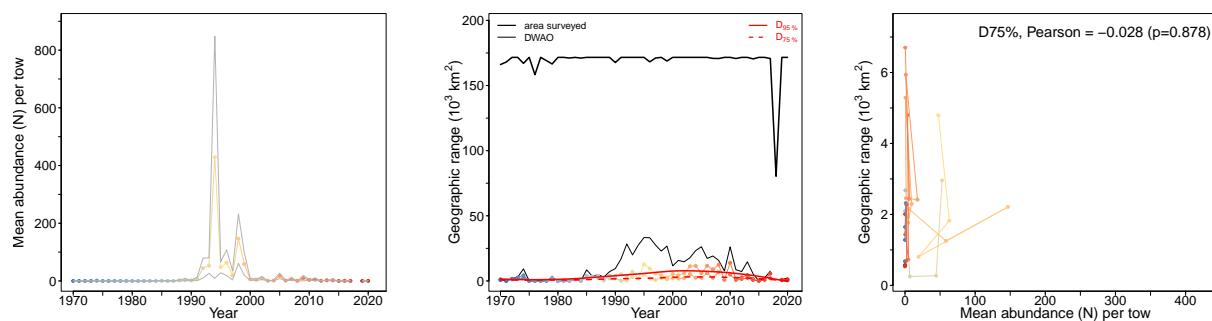


Figure 6.50B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Capelin.

6.51 Northern prawn (Crevette nordique) - species code 2211 (category SF)

Scientific name: [Pandalus borealis](#)

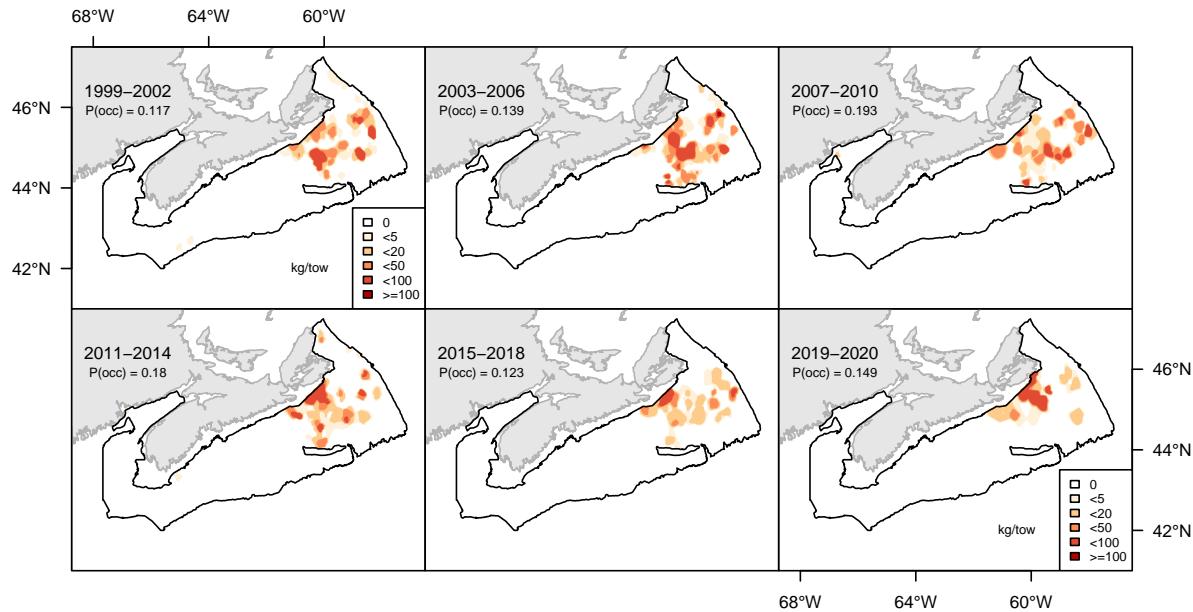


Figure 6.51A. Inverse distance weighted distribution of catch biomass (kg/tow) for Northern prawn.

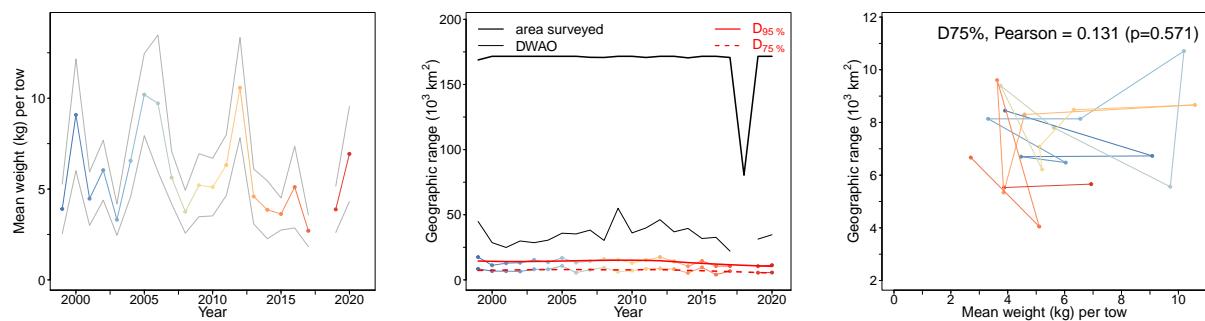


Figure 6.51B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Northern prawn.

6.52 Jonah crab (Crabe nordique) - species code 2511 (category SF)

Scientific name: [Cancer borealis](#)

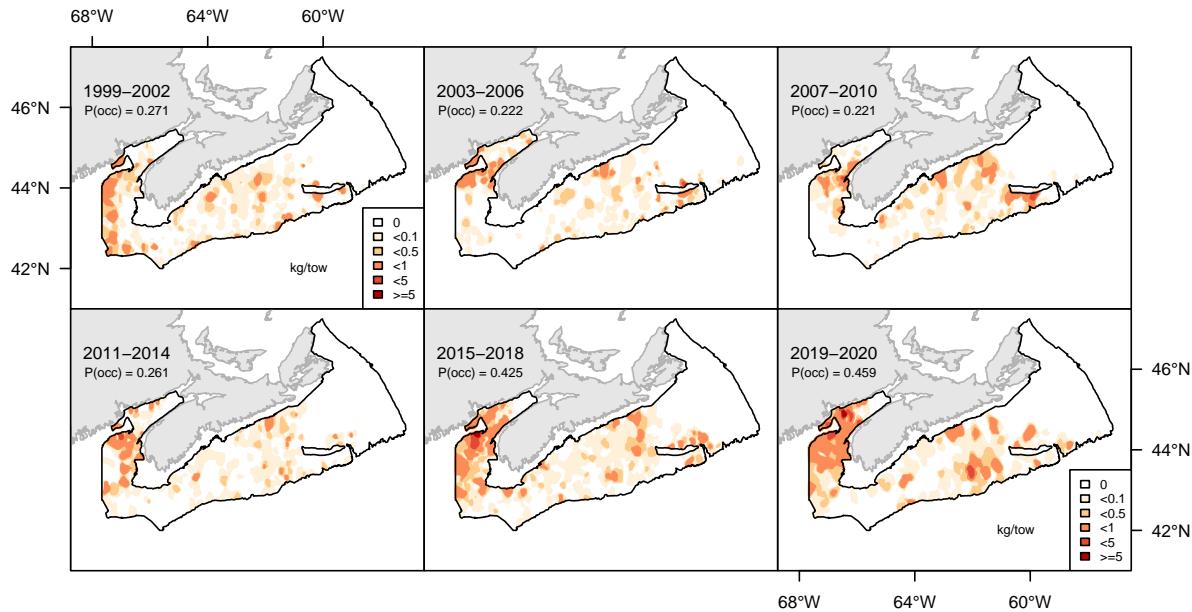


Figure 6.52A. Inverse distance weighted distribution of catch biomass (kg/tow) for Jonah crab.

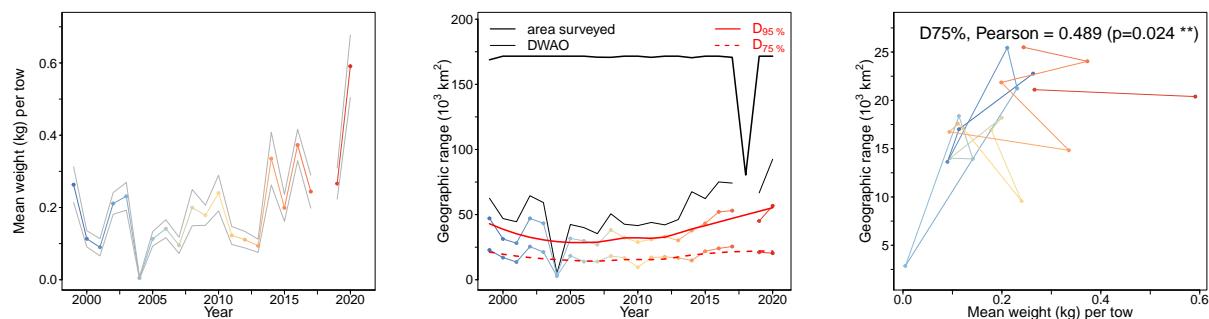


Figure 6.52B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Jonah crab.

6.53 Atlantic rock crab (*Crabe commun*) - species code 2513 (category SF)

Scientific name: [Cancer irroratus](#)

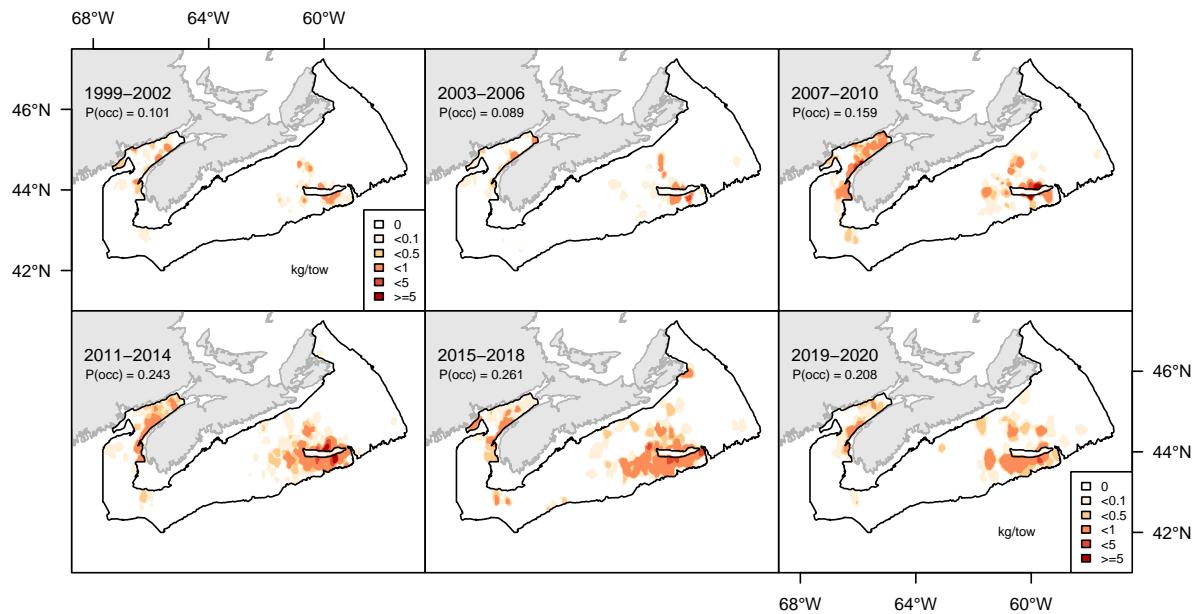


Figure 6.53A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic rock crab.

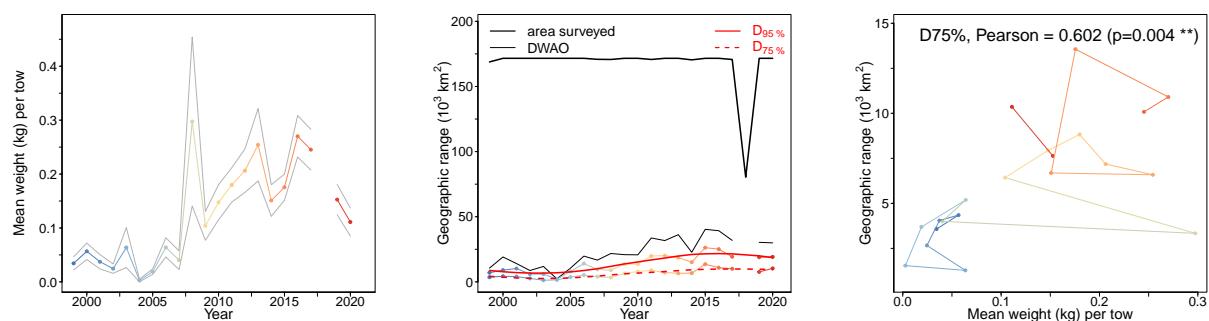


Figure 6.53B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic rock crab.

6.54 Arctic lyre crab (*Crabe Hyas coarctatus*) - species code 2521 (category SF)

Scientific name: [Hyas coarctatus](#)

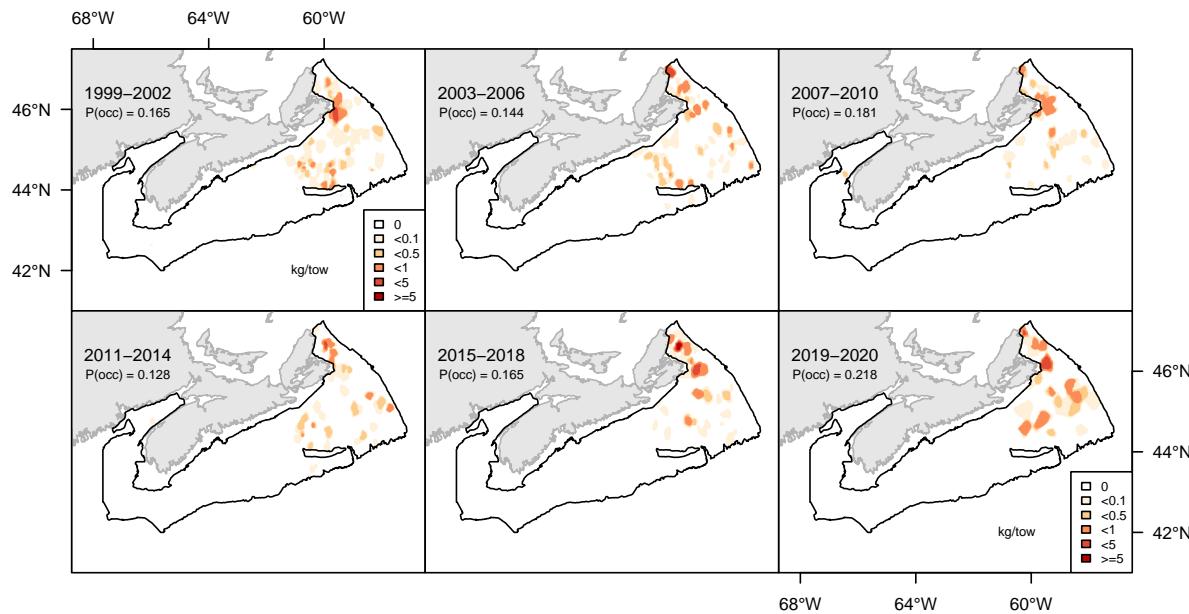


Figure 6.54A. Inverse distance weighted distribution of catch biomass (kg/tow) for Arctic lyre crab.

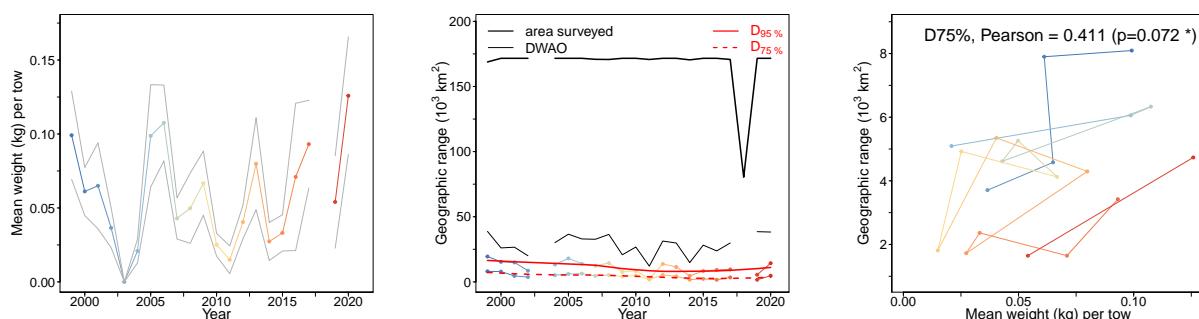


Figure 6.54B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Arctic lyre crab.

6.55 Atlantic king crab (Crabe épineux du nord) - species code 2523 (category SF)

Scientific name: [Lithodes maja](#)

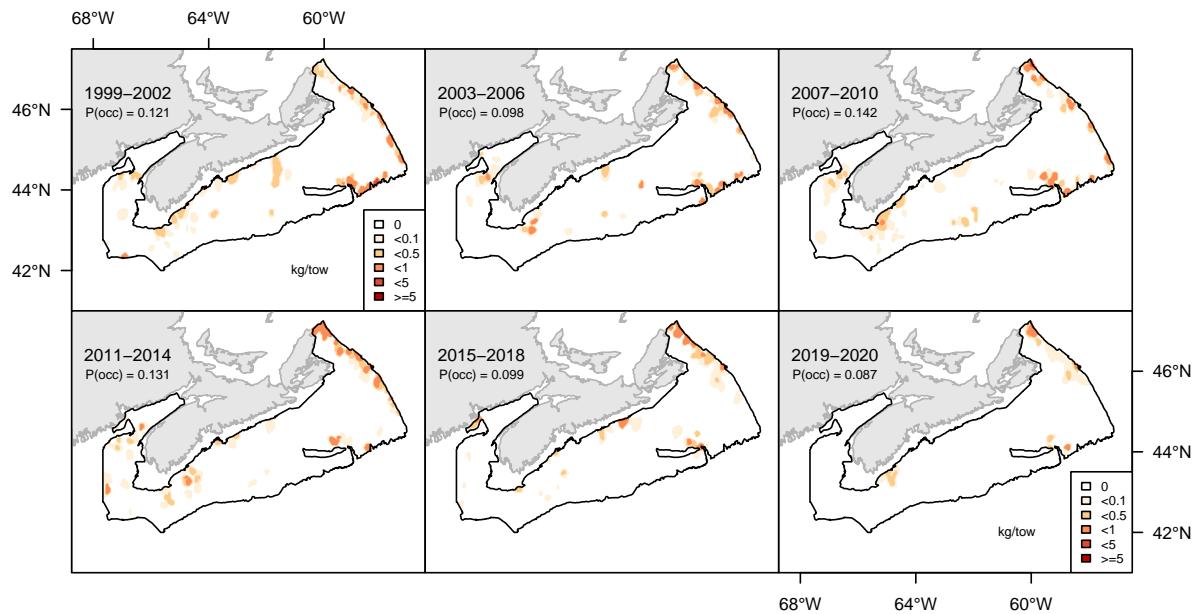


Figure 6.55A. Inverse distance weighted distribution of catch biomass (kg/tow) for Atlantic king crab.

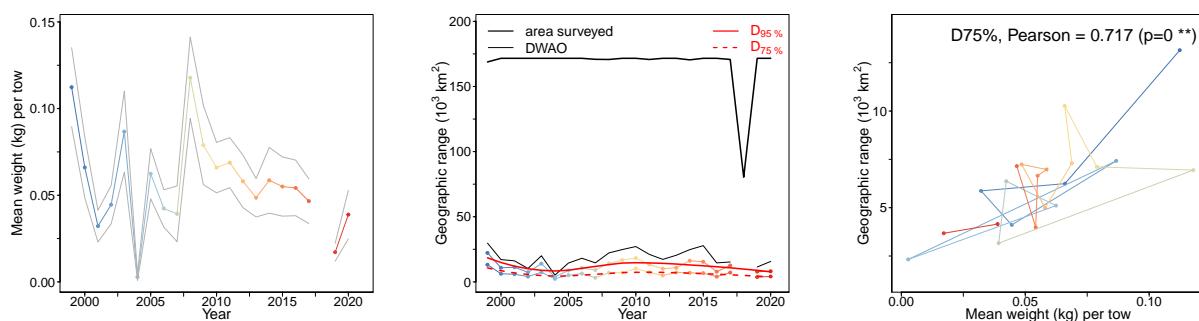


Figure 6.55B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Atlantic king crab.

6.56 Queen crab (Crabe des neiges) - species code 2526 (category SF)

Scientific name: [Chionoecetes opilio](#)

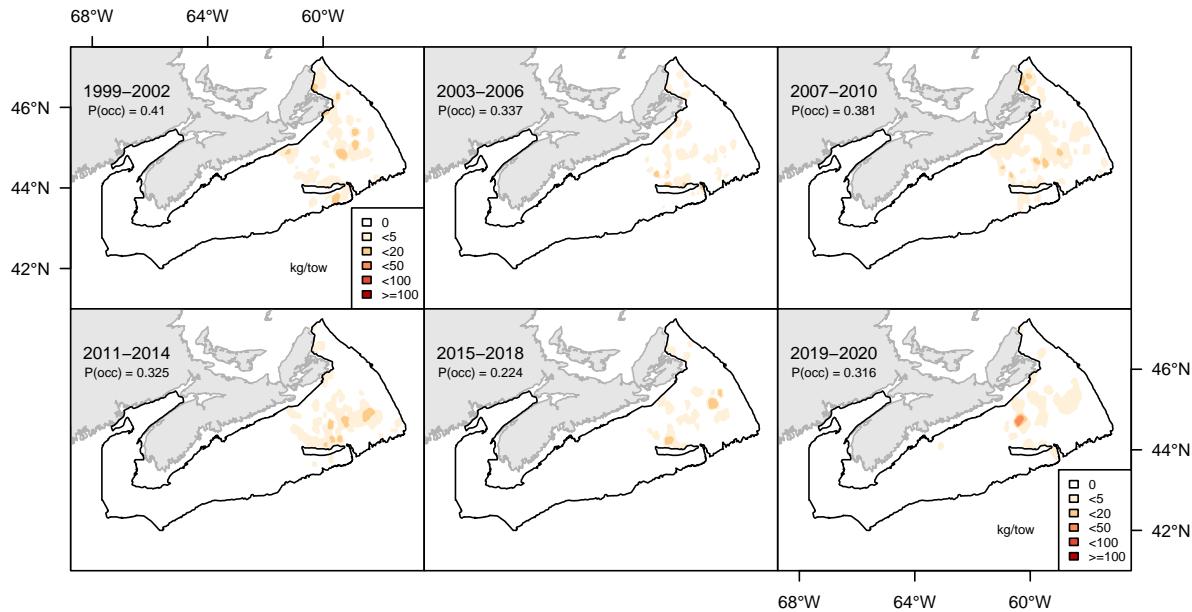


Figure 6.56A. Inverse distance weighted distribution of catch biomass (kg/tow) for Queen crab.

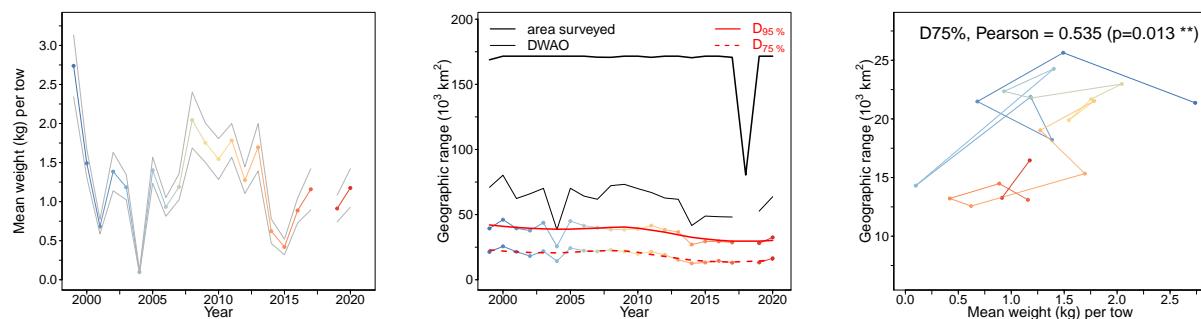


Figure 6.56B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Queen crab.

6.57 Great spider crab (Crabe lyre araignée) - species code 2527 (category SF)

Scientific name: [Hyas araneus](#)

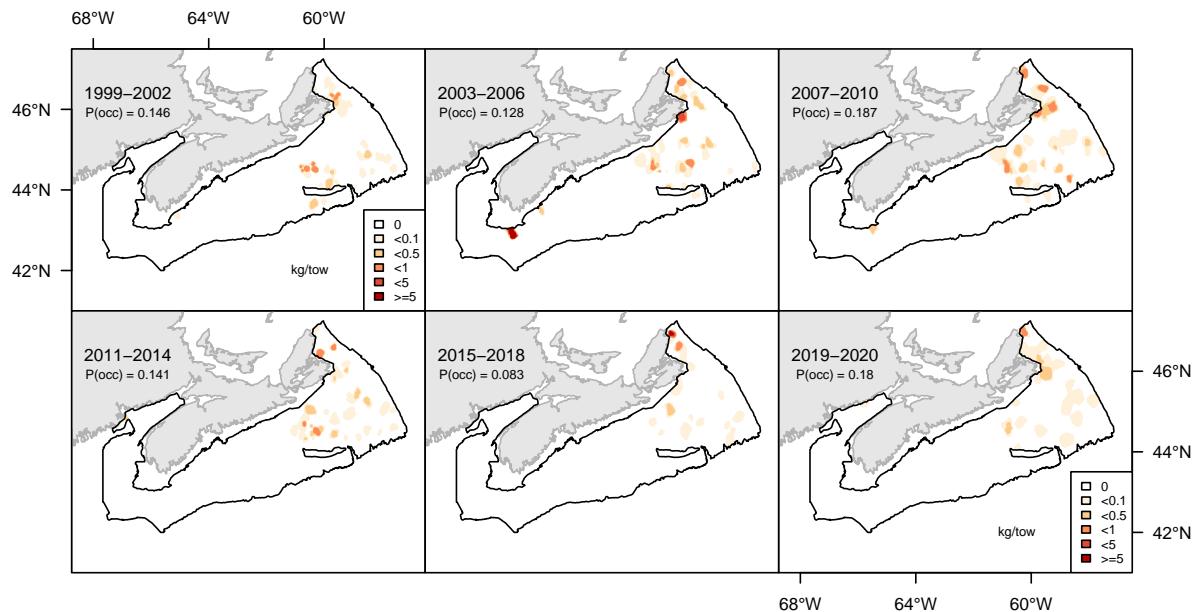


Figure 6.57A. Inverse distance weighted distribution of catch biomass (kg/tow) for Great spider crab.

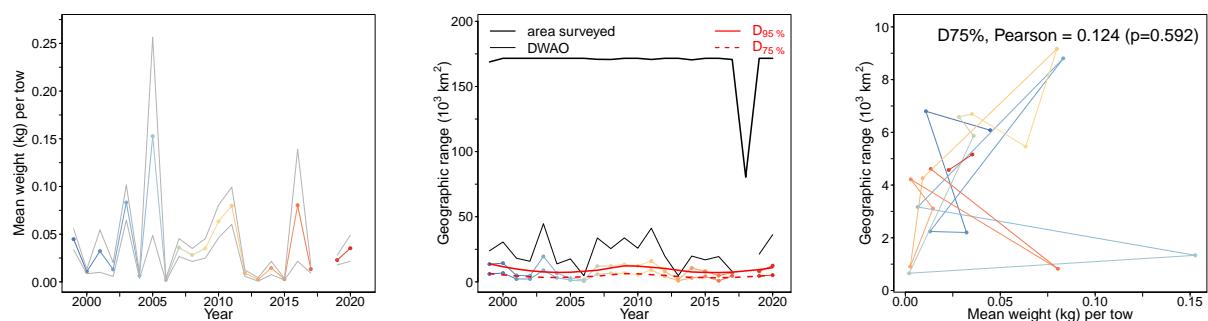


Figure 6.57B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of Great spider crab.

6.58 American lobster (Homard américain) - species code 2550 (category SF)

Scientific name: [Homarus americanus](#)

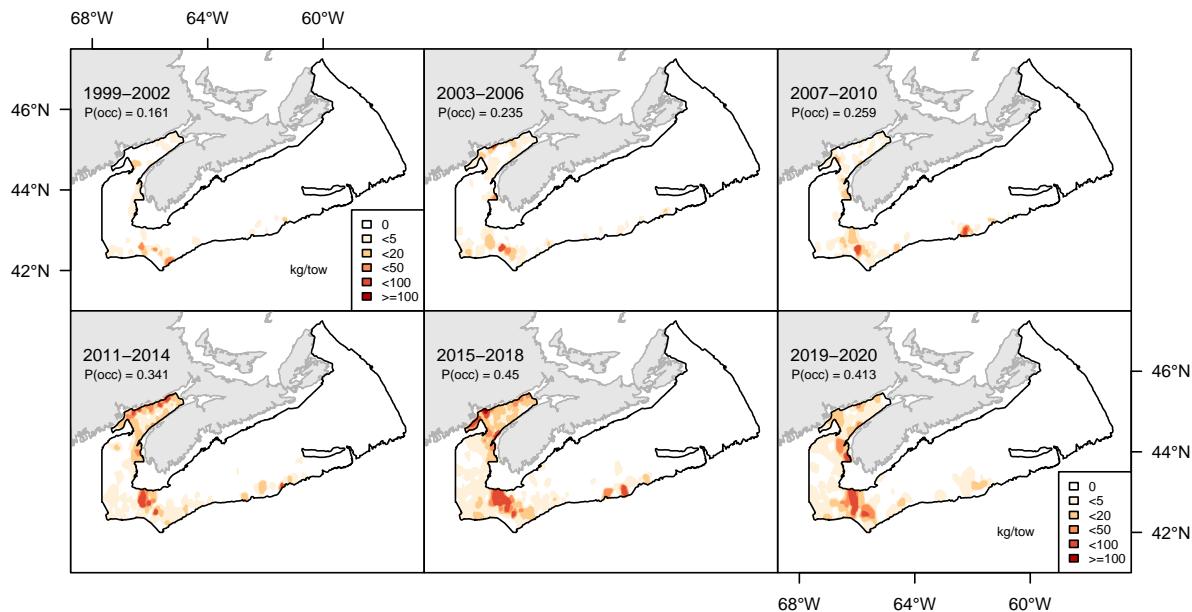


Figure 6.58A. Inverse distance weighted distribution of catch biomass (kg/tow) for American lobster.

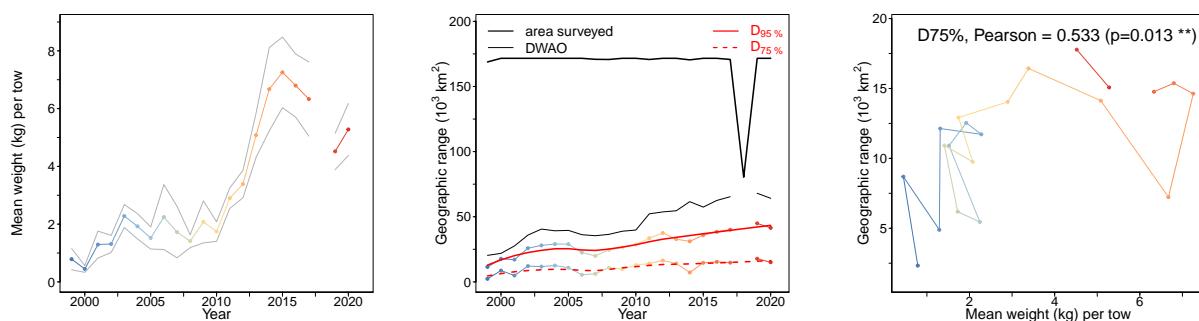


Figure 6.58B. Stratified random estimates of biomass (kg/tow), D75 and D95 and the correlation between D75 and biomass of American lobster.

6.59 Sea lamprey (*Lamproie marine*) - species code 240 (category LR)

Scientific name: [Petromyzon marinus](#)

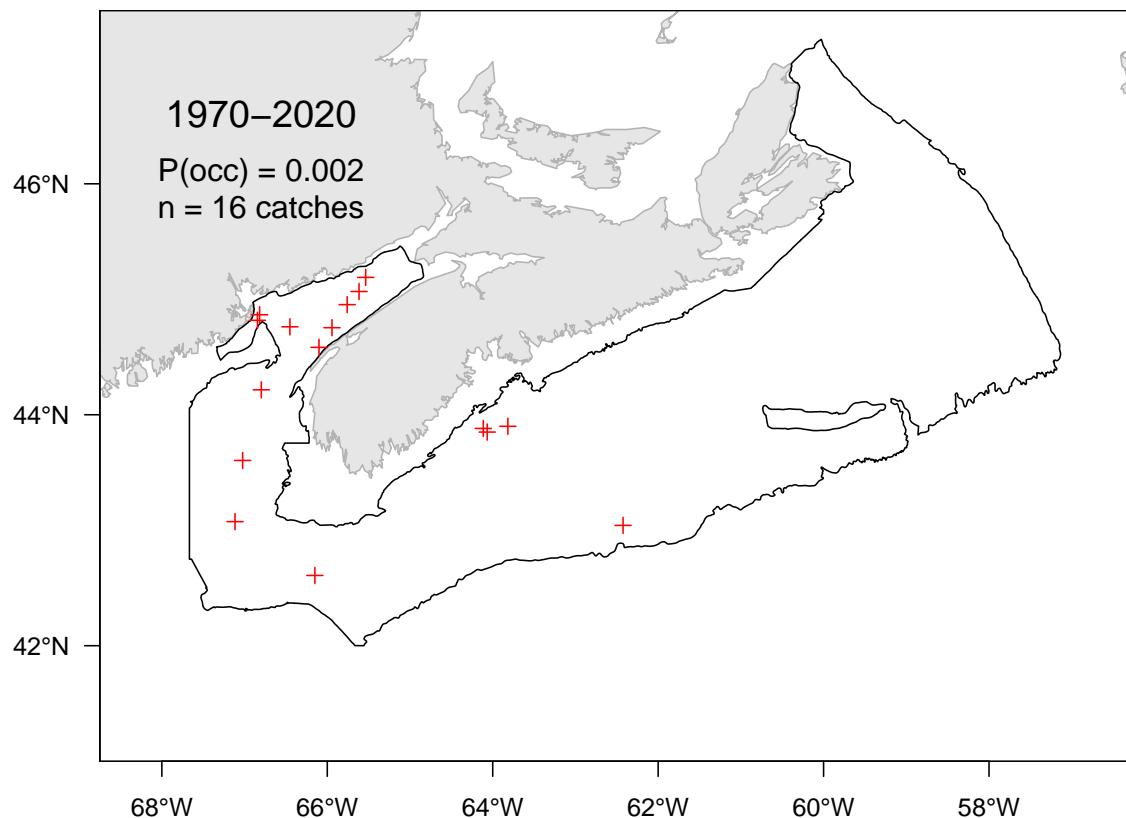


Figure 6.59A. Catch distribution for Sea lamprey.

6.60 Atlantic tomcod (*Poulamon atlantique*) - species code 17 (category LR)

Scientific name: [*Microgadus tomcod*](#)

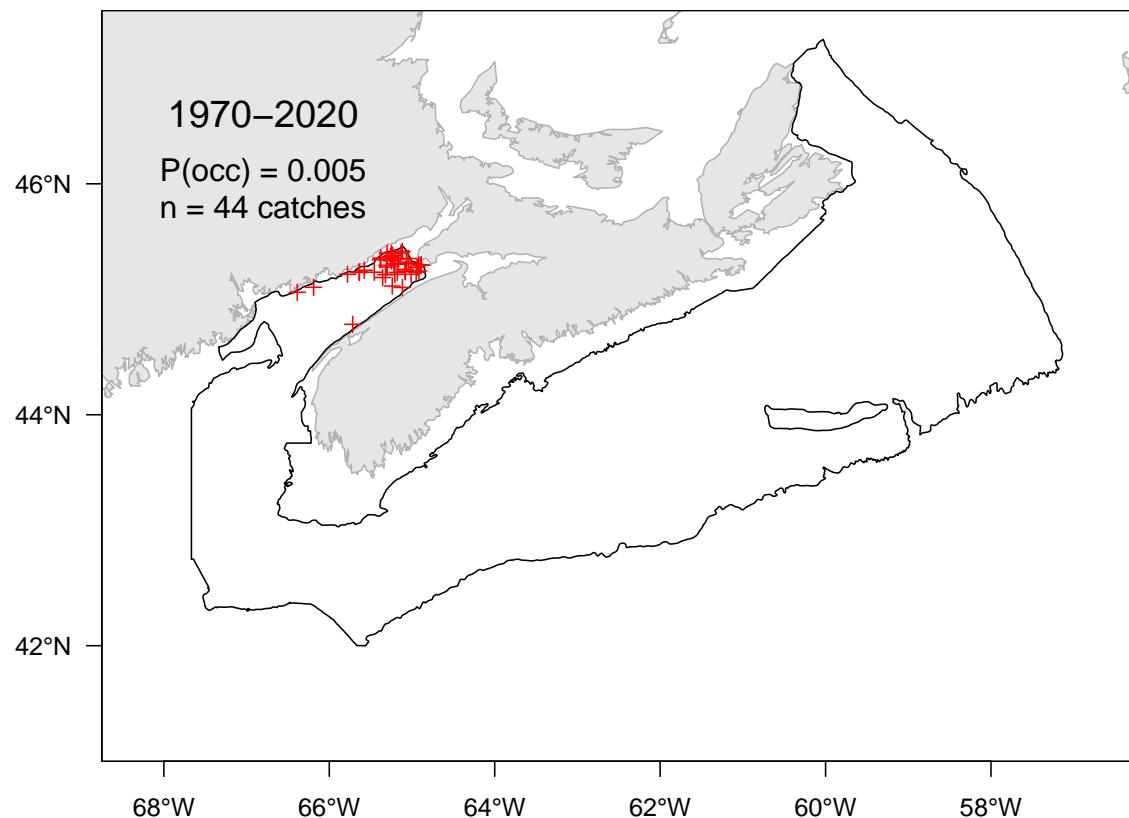


Figure 6.60A. Catch distribution for Atlantic tomcod.

6.61 Offshore silver hake (Merlu argenté du large) - species code 19 (category LR)

Scientific name: [Merluccius albidus](#)

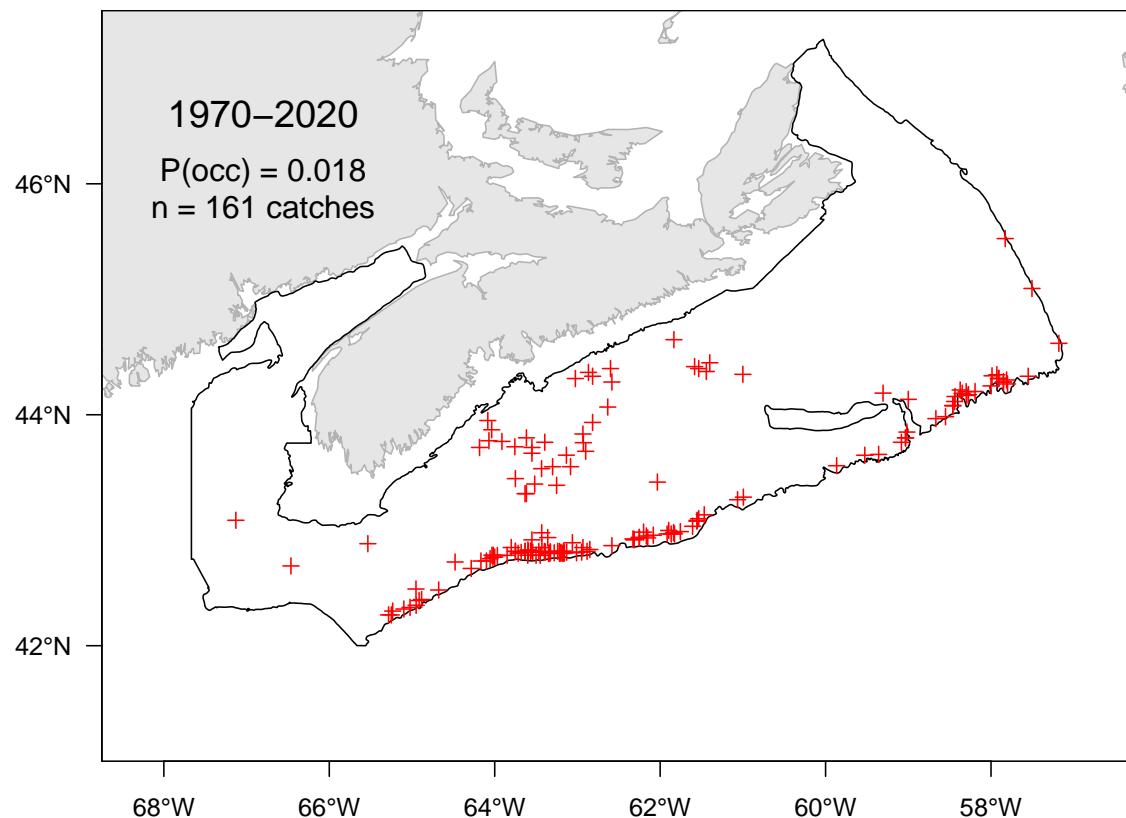


Figure 6.61A. Catch distribution for Offshore silver hake.

6.62 Roughnose grenadier (Grenadier-scie) - species code 412 (category LR)

Scientific name: [Trachyrincus murrayi](#)

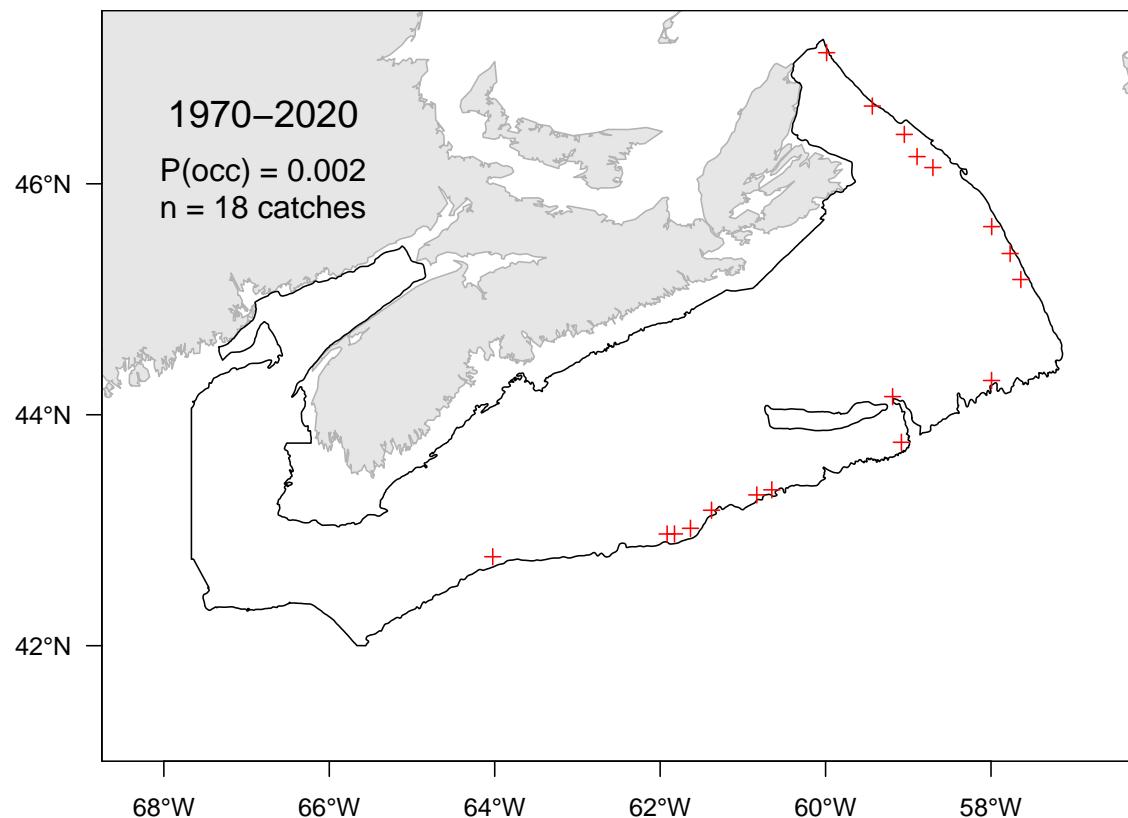


Figure 6.62A. Catch distribution for Roughnose grenadier.

6.63 Roundnose grenadier (Grenadier de roche) - species code 414 (category LR)

Scientific name: [Coryphaenoides rupestris](#)

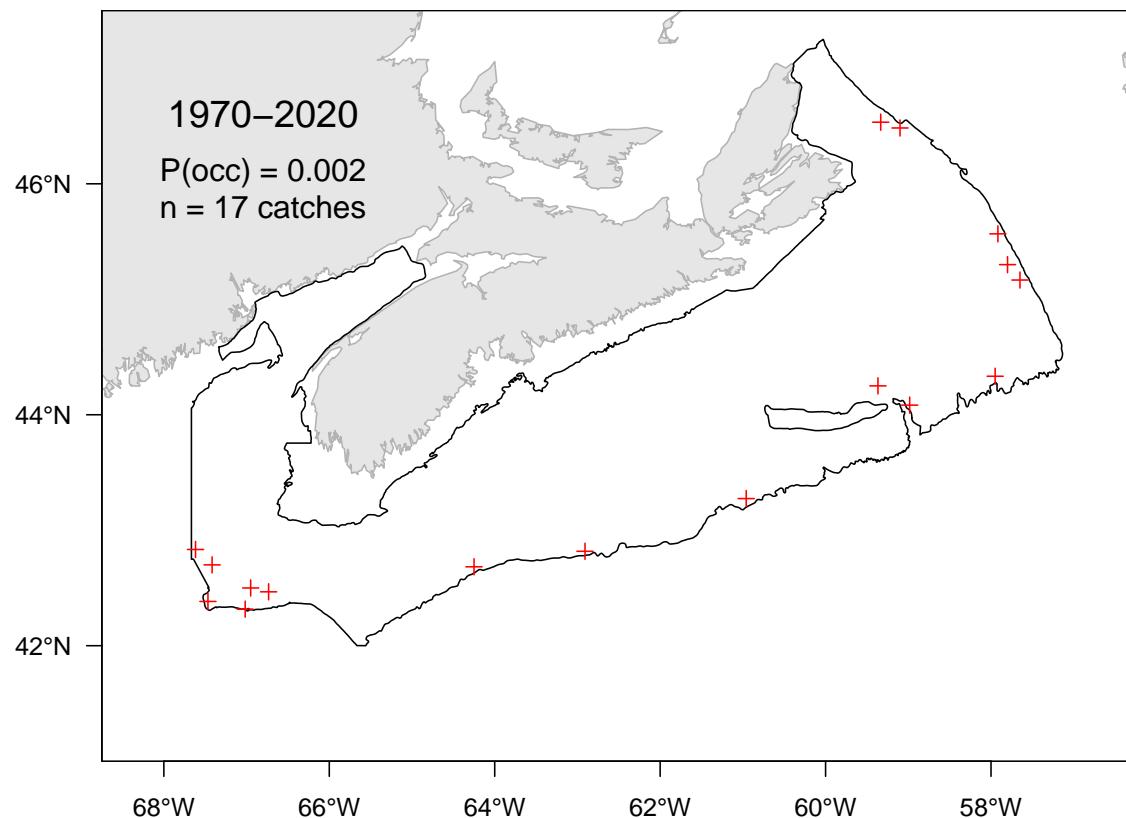


Figure 6.63A. Catch distribution for Roundnose grenadier.

6.64 Fourspot flounder (Cardeau à quatre ocelles) - species code 142 (category LR)

Scientific name: [Hippoglossina oblonga](#)

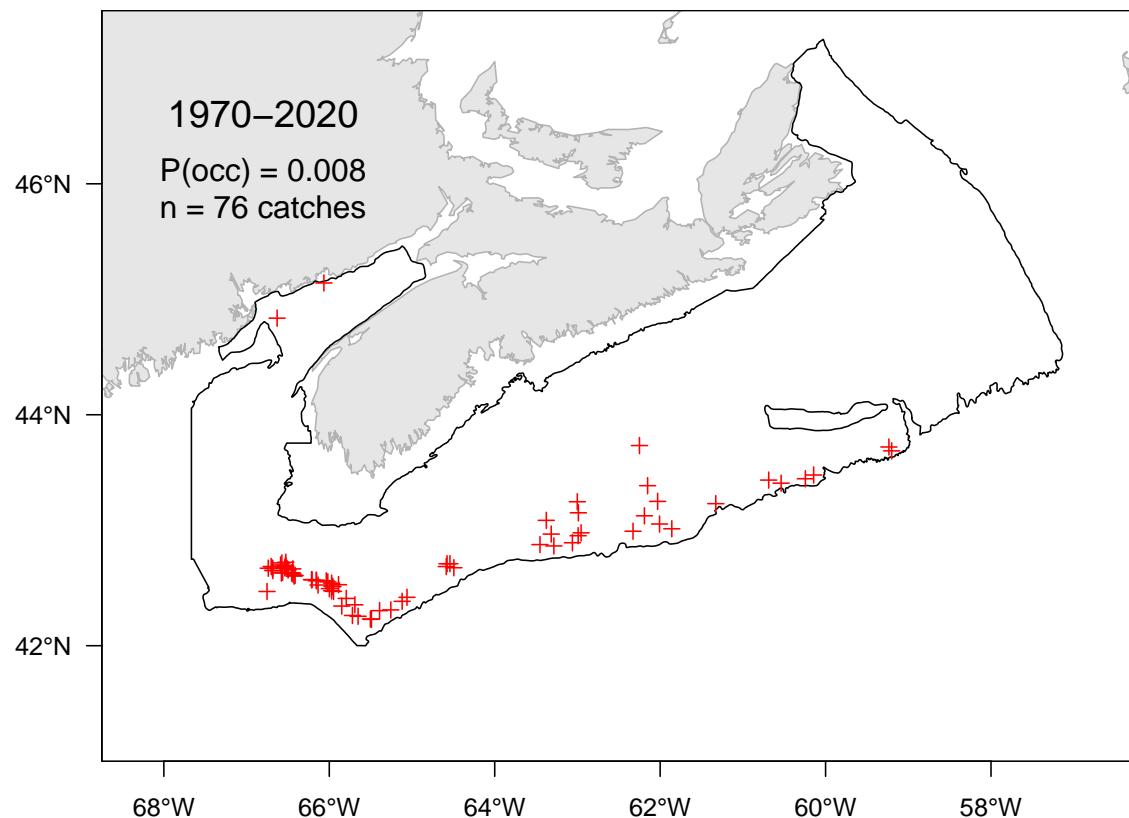


Figure 6.64A. Catch distribution for Fourspot flounder.

6.65 Windowpane flounder (Turbot de sable) - species code 143 (category LR)

Scientific name: [Scophthalmus aquosus](#)

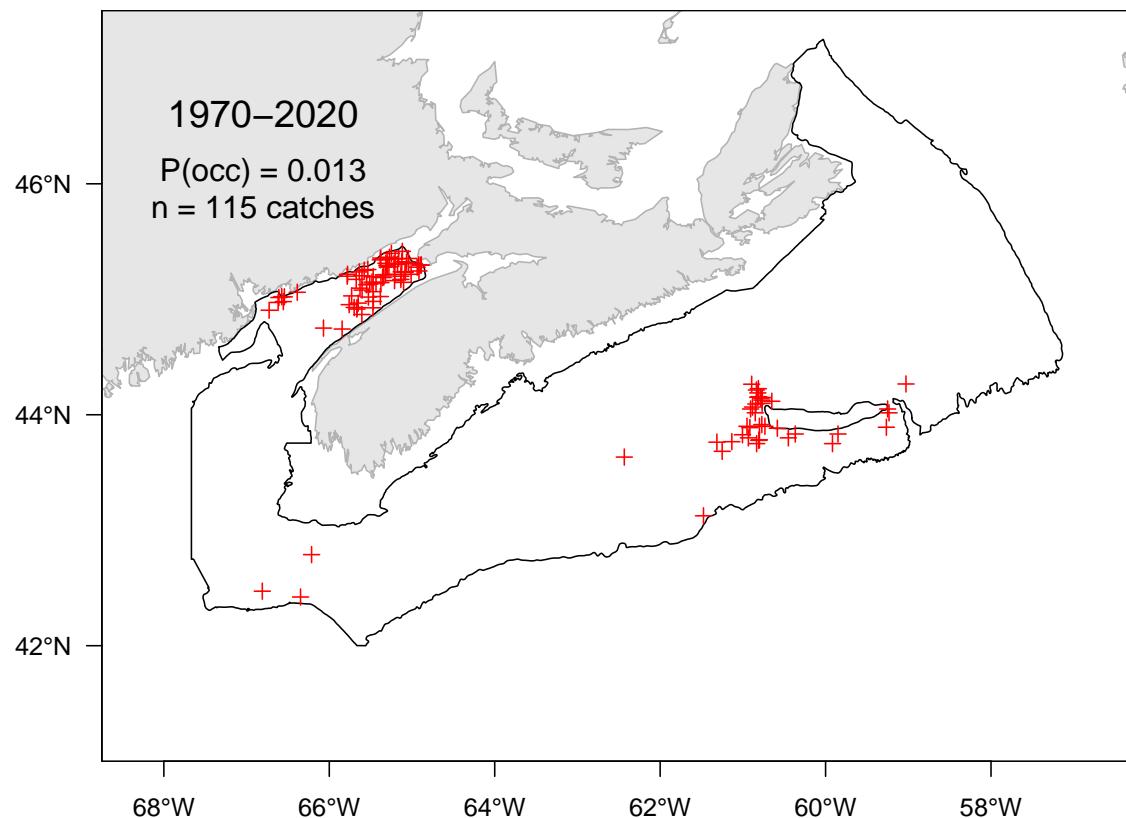


Figure 6.65A. Catch distribution for Windowpane flounder.

6.66 Spottedfin tonguefish (Langue fil noir) - species code 816 (category LR)

Scientific name: [Syphurus diomedeanus](#)

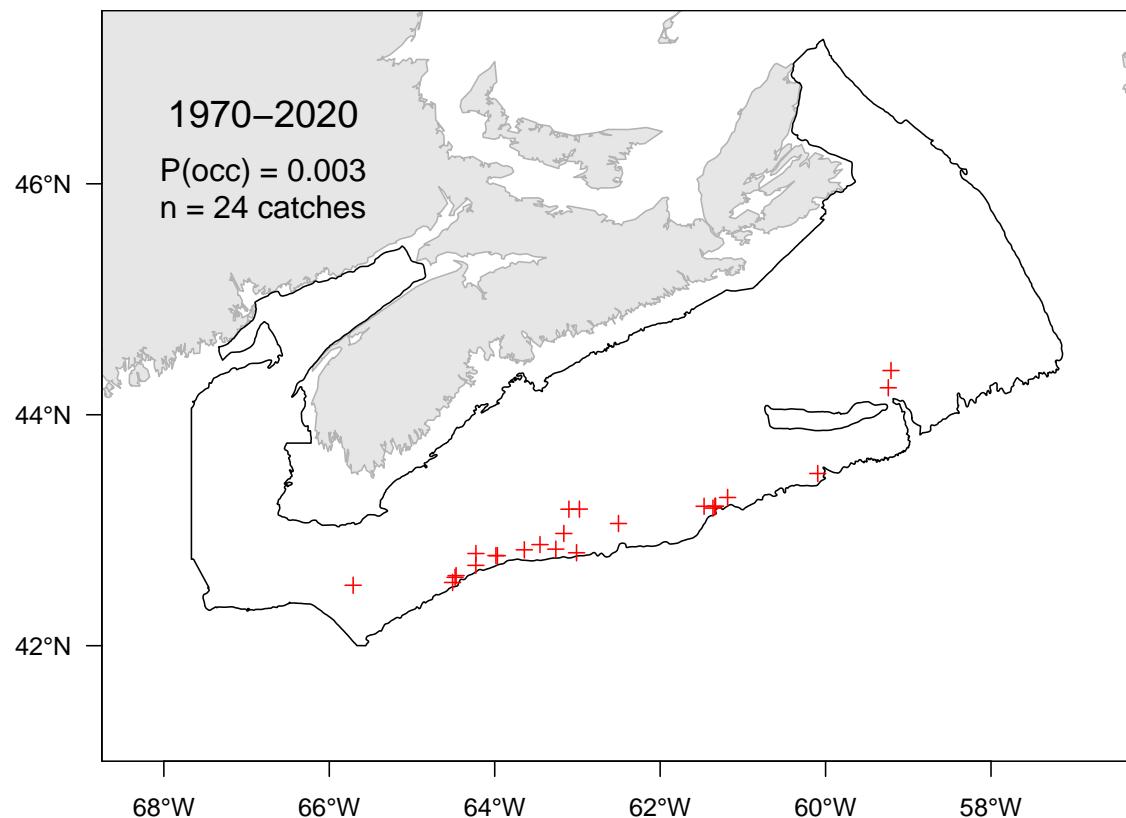


Figure 6.66A. Catch distribution for Spottedfin tonguefish.

6.67 Spotted wolffish (Loup tacheté) - species code 51 (category LR)

Scientific name: [Anarhichas minor](#)

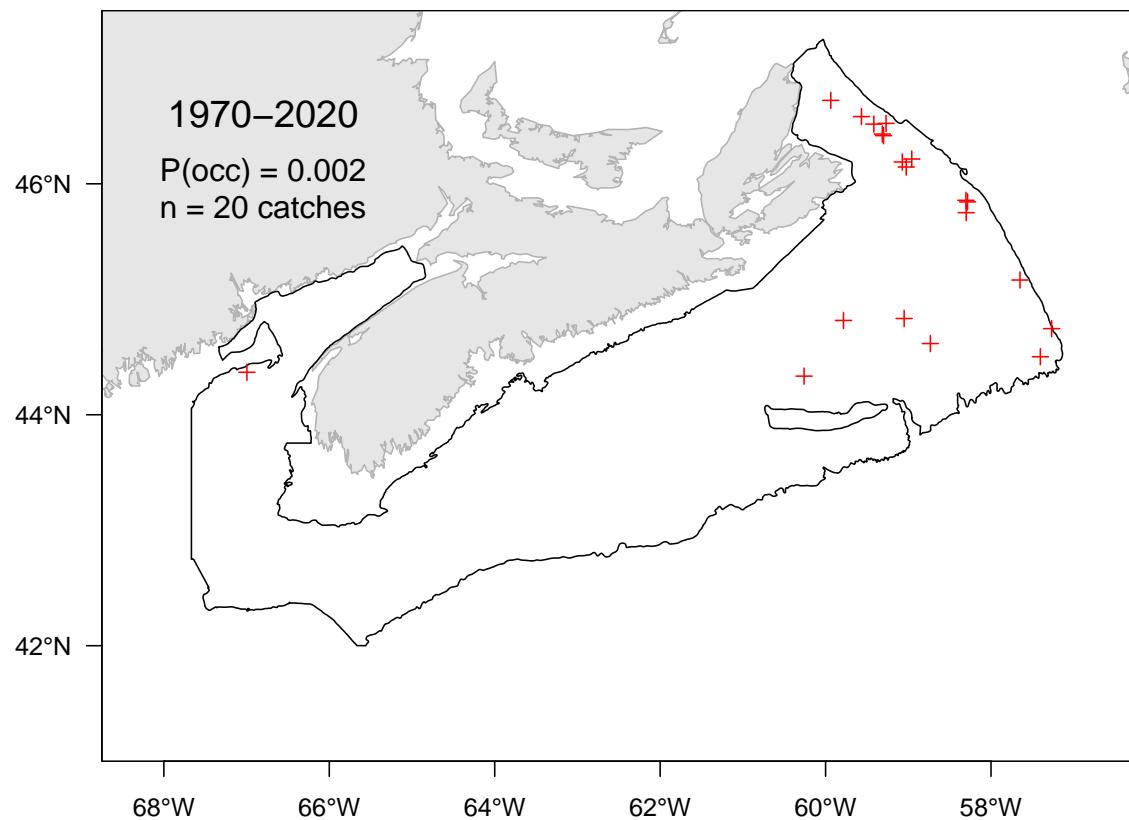


Figure 6.67A. Catch distribution for Spotted wolffish.

6.68 Northern wolffish (Loup à tête large) - species code 52 (category LR)

Scientific name: [Anarhichas denticulatus](#)

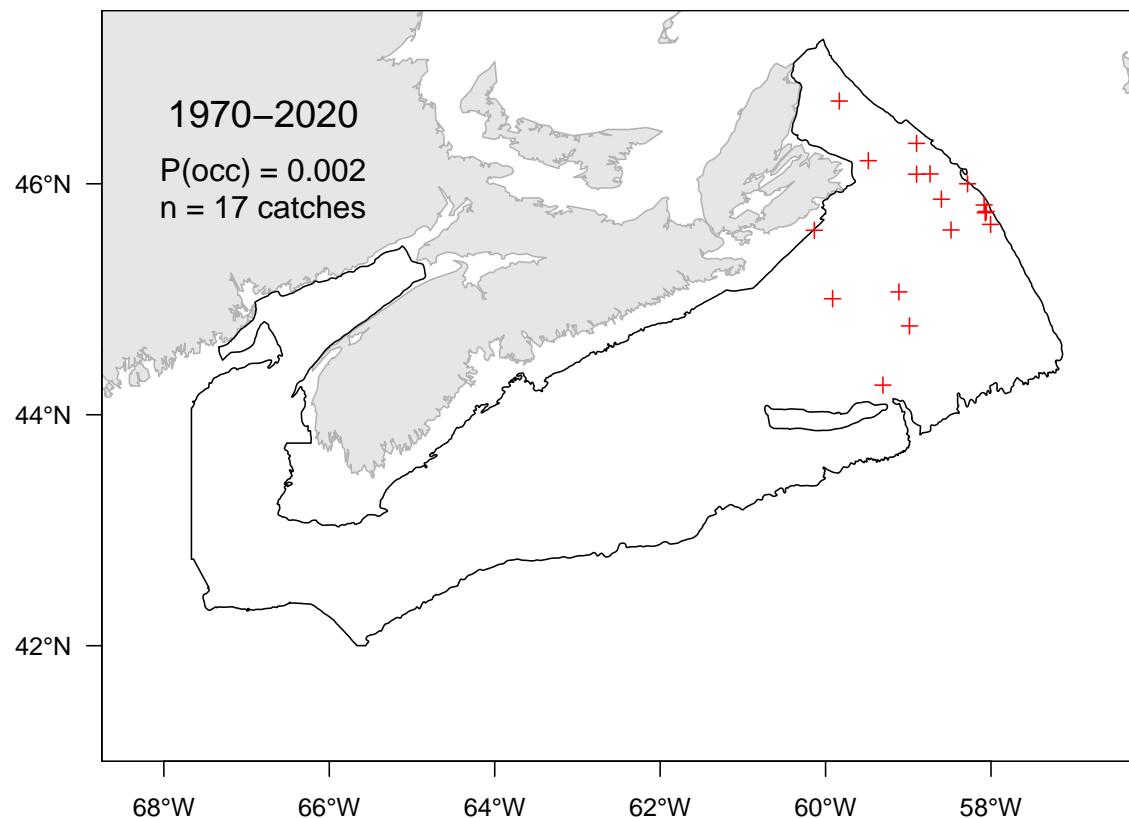


Figure 6.68A. Catch distribution for Northern wolffish.

6.69 Shorthorn sculpin (Chabotisseau à épines courtes) - species code 301 (category LR)

Scientific name: [Myoxocephalus scorpius](#)

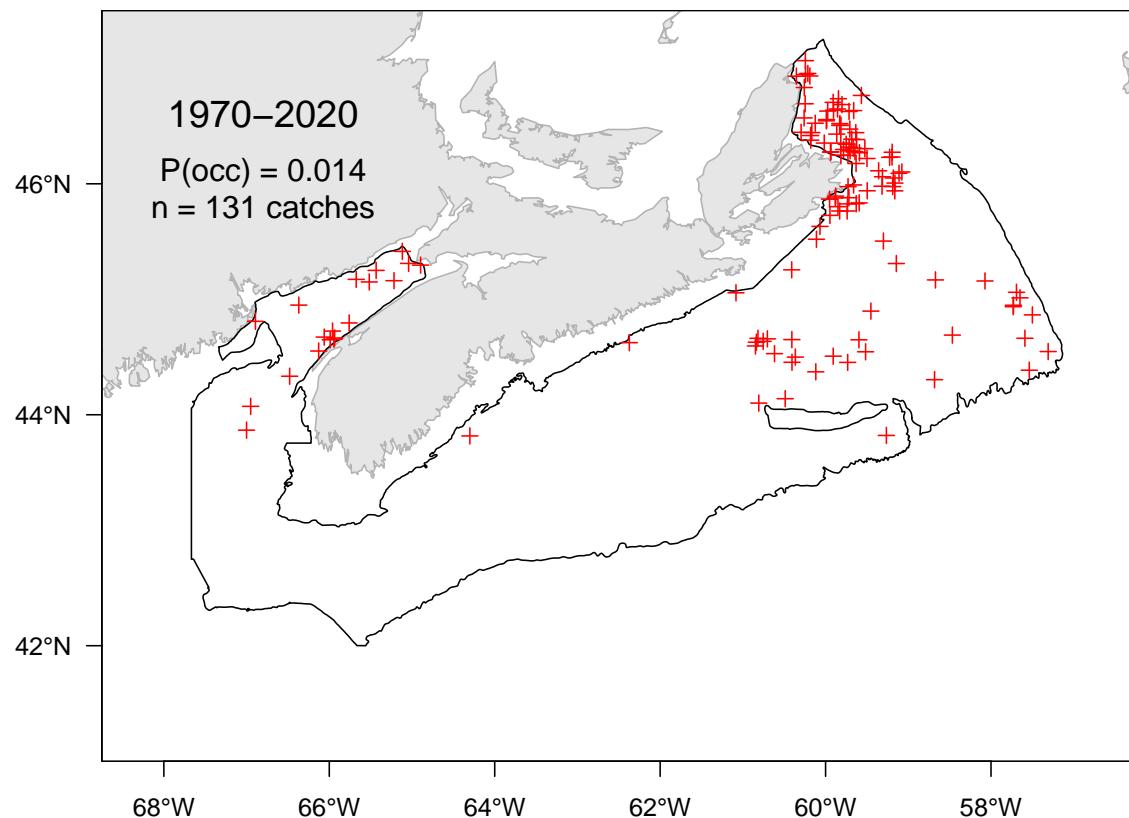


Figure 6.69A. Catch distribution for Shorthorn sculpin.

6.70 Grubby (Chabosseau bronzé) - species code 303 (category LR)

Scientific name: [Myoxocephalus aenaeus](#)

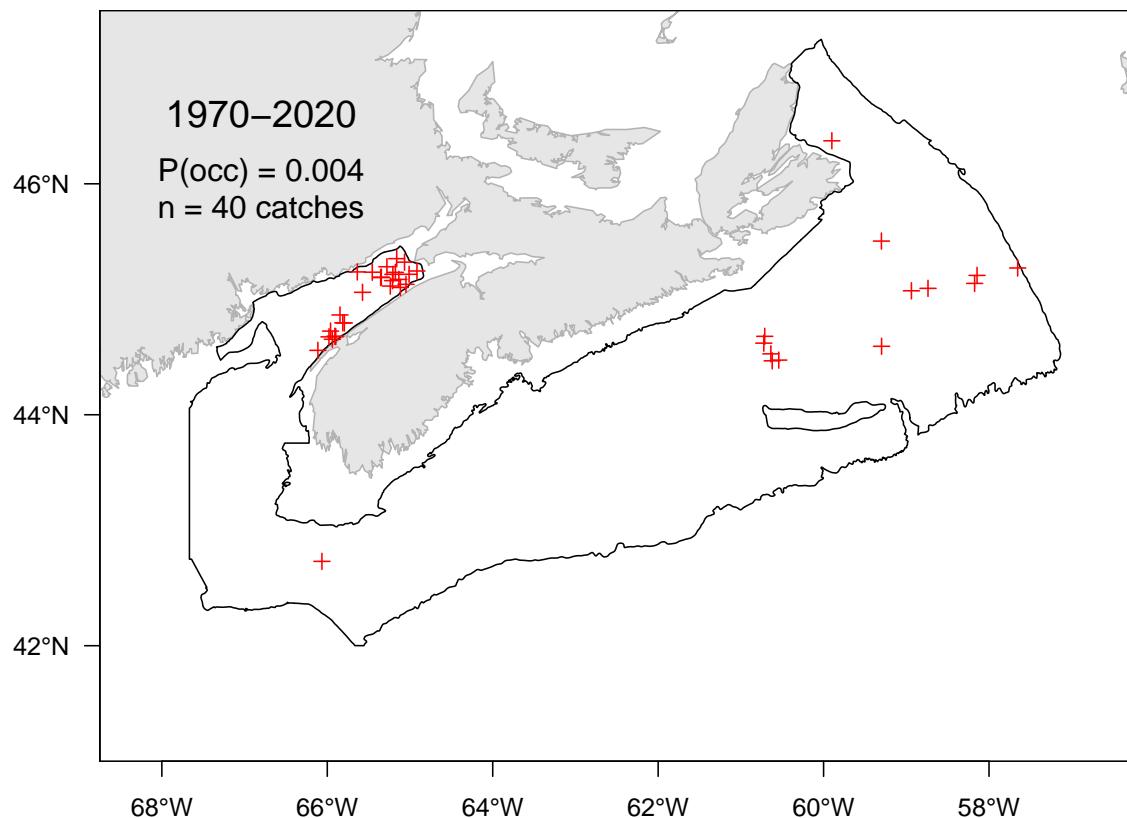


Figure 6.70A. Catch distribution for Grubby.

6.71 Polar sculpin (Cotte polaire) - species code 307 (category LR)

Scientific name: [Cottunculus microps](#)

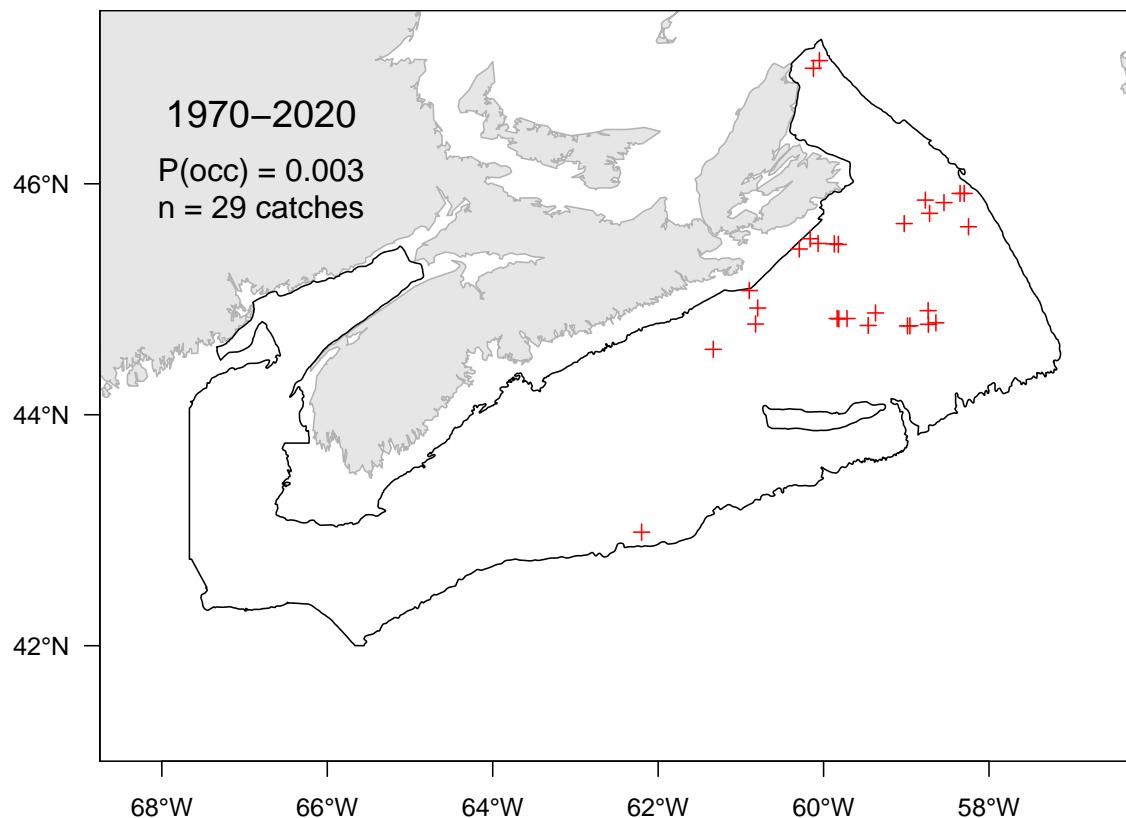


Figure 6.71A. Catch distribution for Polar sculpin.

6.72 Spatulate sculpin (Icèle spatulée) - species code 314 (category LR)

Scientific name: [Icelus spatula](#)

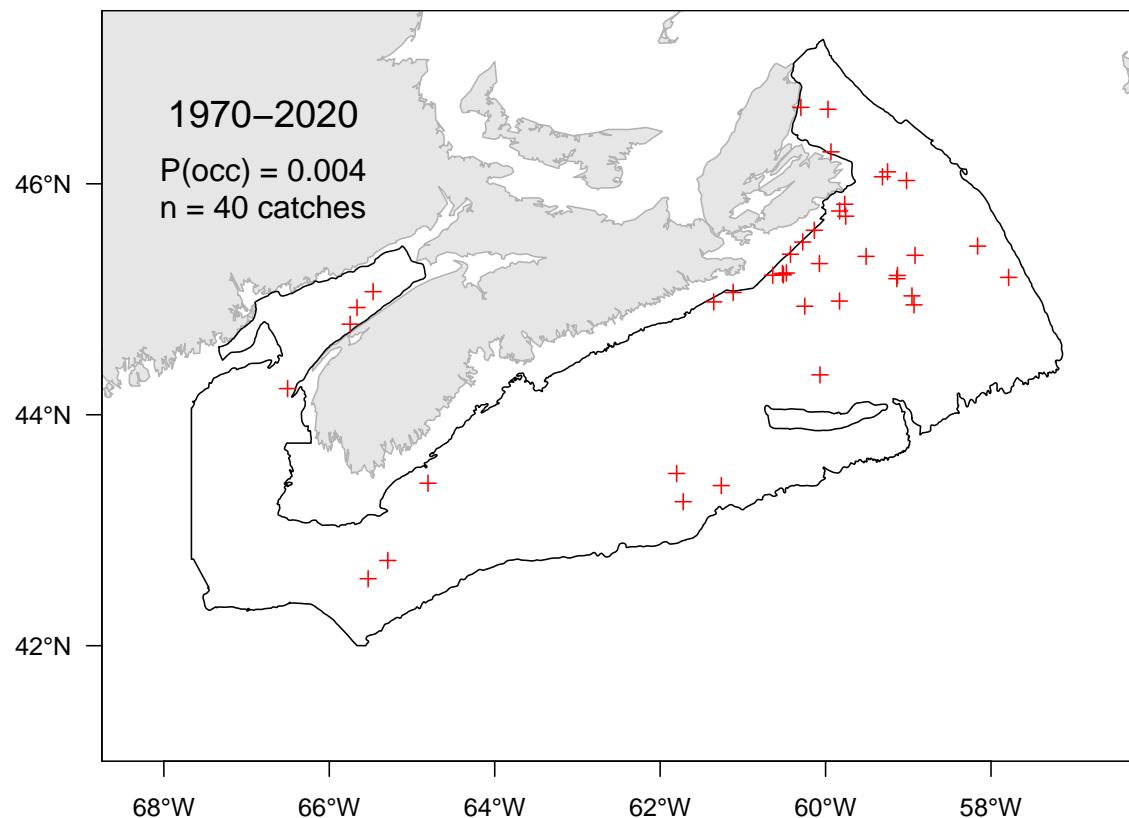


Figure 6.72A. Catch distribution for Spatulate sculpin.

6.73 Arctic alligatorfish (Poisson-alligator arctique) - species code 341 (category LR)

Scientific name: [*Ulcina olrikii*](#)

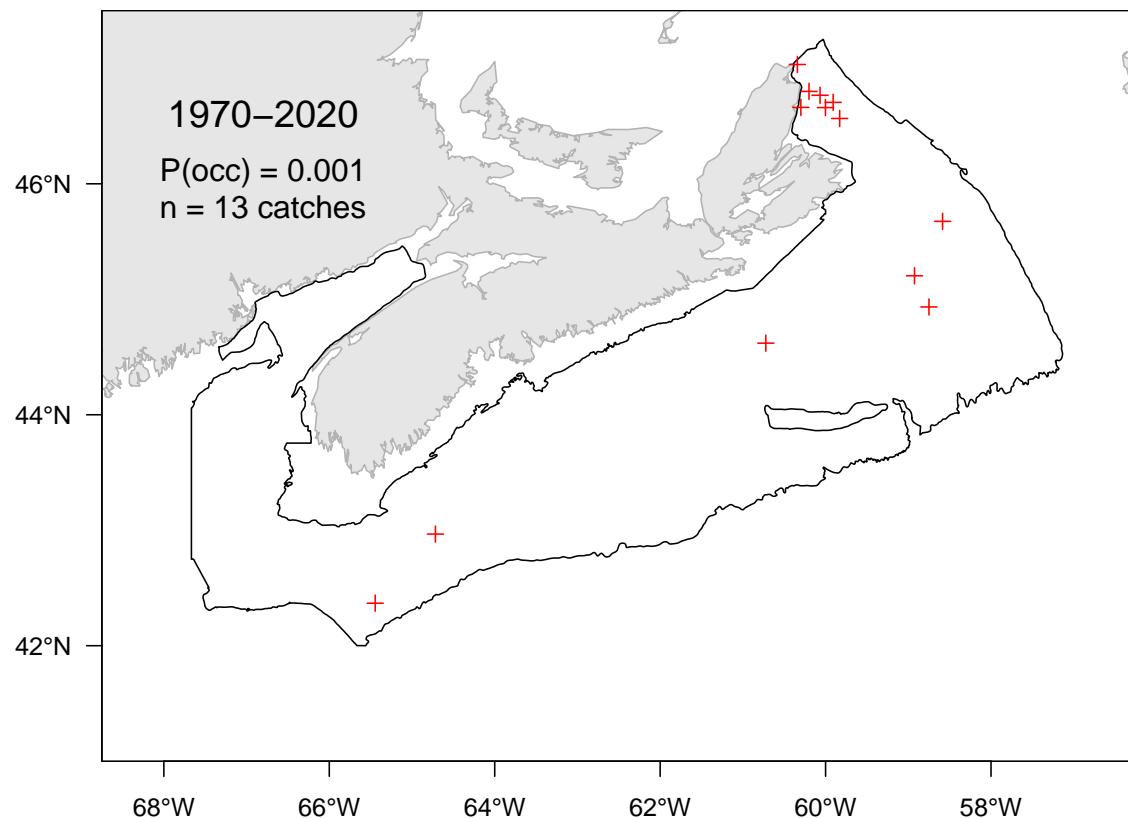


Figure 6.73A. Catch distribution for Arctic alligatorfish.

6.74 Atlantic seasnail (*Limace atlantique*) - species code 503 (category LR)

Scientific name: [Liparis atlanticus](#)

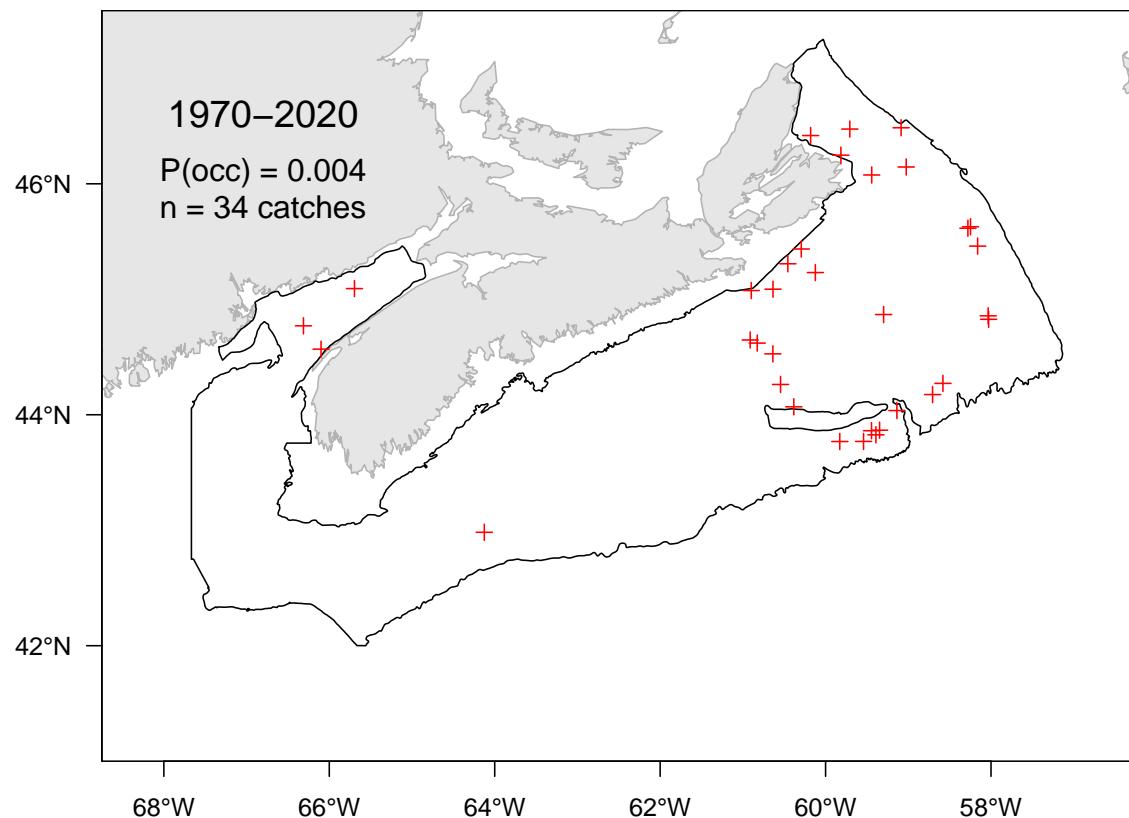


Figure 6.74A. Catch distribution for Atlantic seasnail.

6.75 Gelatinous snailfish (*Limace gélatineuse*) - species code 505 (category LR)

Scientific name: [Liparis fabricii](#)

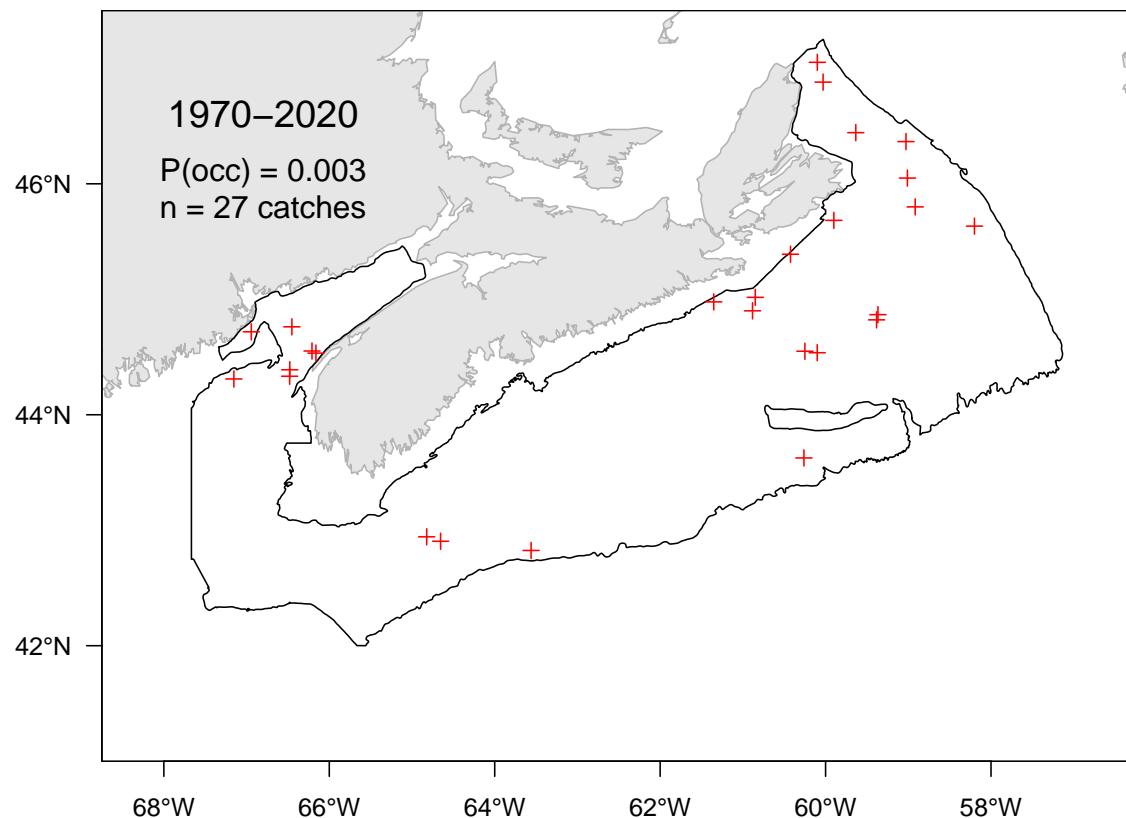


Figure 6.75A. Catch distribution for Gelatinous snailfish.

6.76 Variegated snailfish (*Limace marbée*) - species code 512 (category LR)

Scientific name: [Liparis gibbus](#)

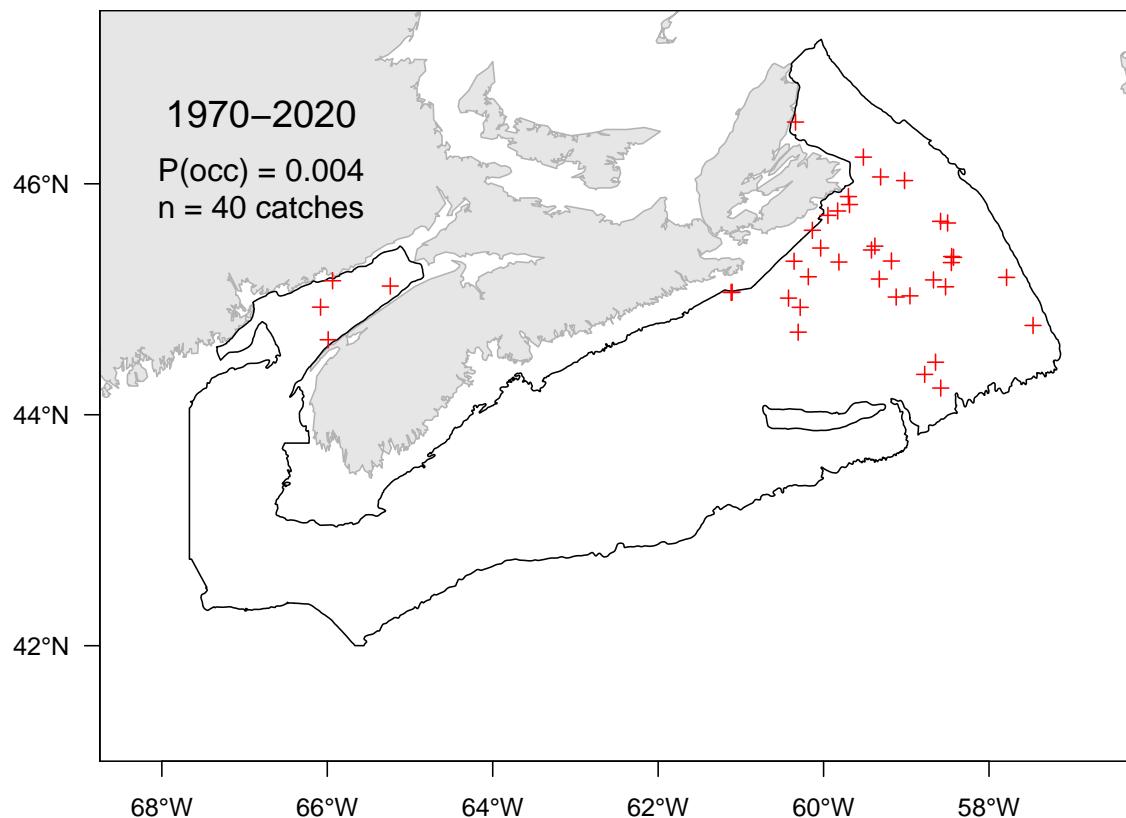


Figure 6.76A. Catch distribution for Variegated snailfish.

6.77 Sea tadpole (Petite limace de mer) - species code 520 (category LR)

Scientific name: [Careproctus reinhardti](#)

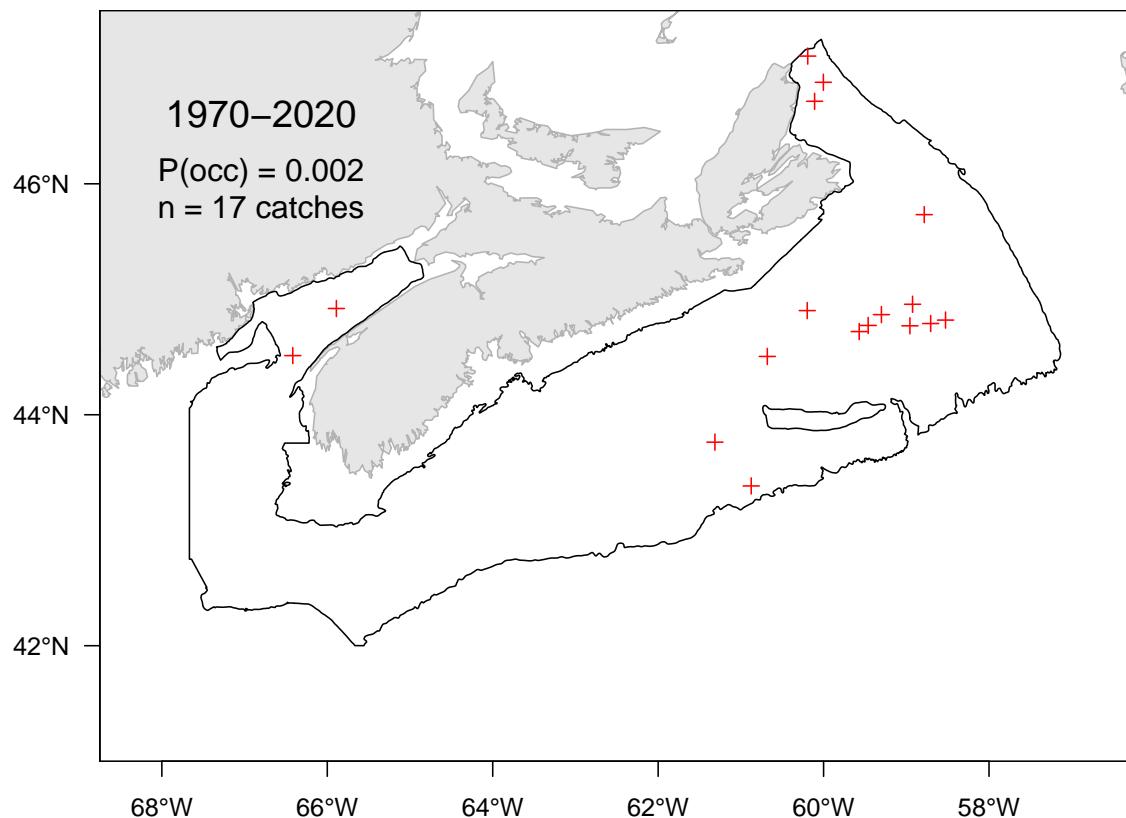


Figure 6.77A. Catch distribution for Sea tadpole.

6.78 Wolf eelpout (*Lycodes à tête longue*) - species code 603 (category LR)

Scientific name: [*Lycenchelys verrillii*](#)

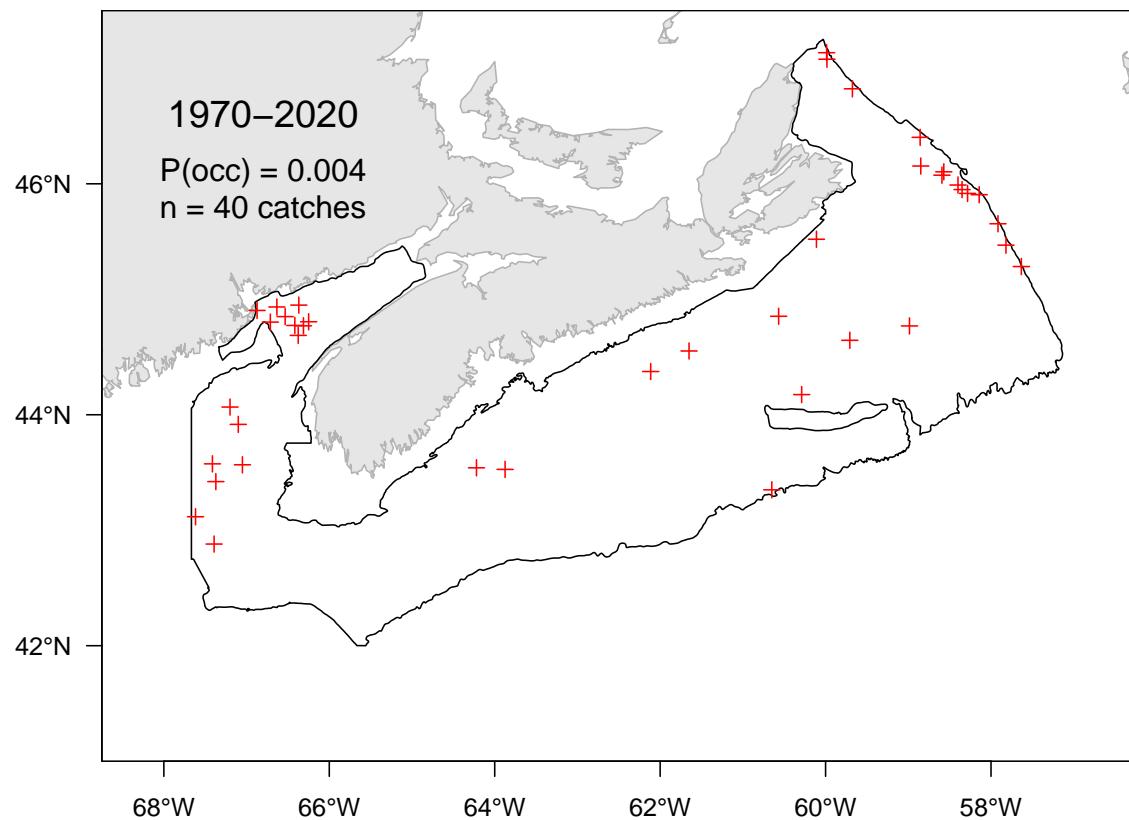


Figure 6.78A. Catch distribution for Wolf eelpout.

6.79 Newfoundland eelpout (Lycodes du Labrador) - species code 619 (category LR)

Scientific name: [Lycodes terraenovae](#)

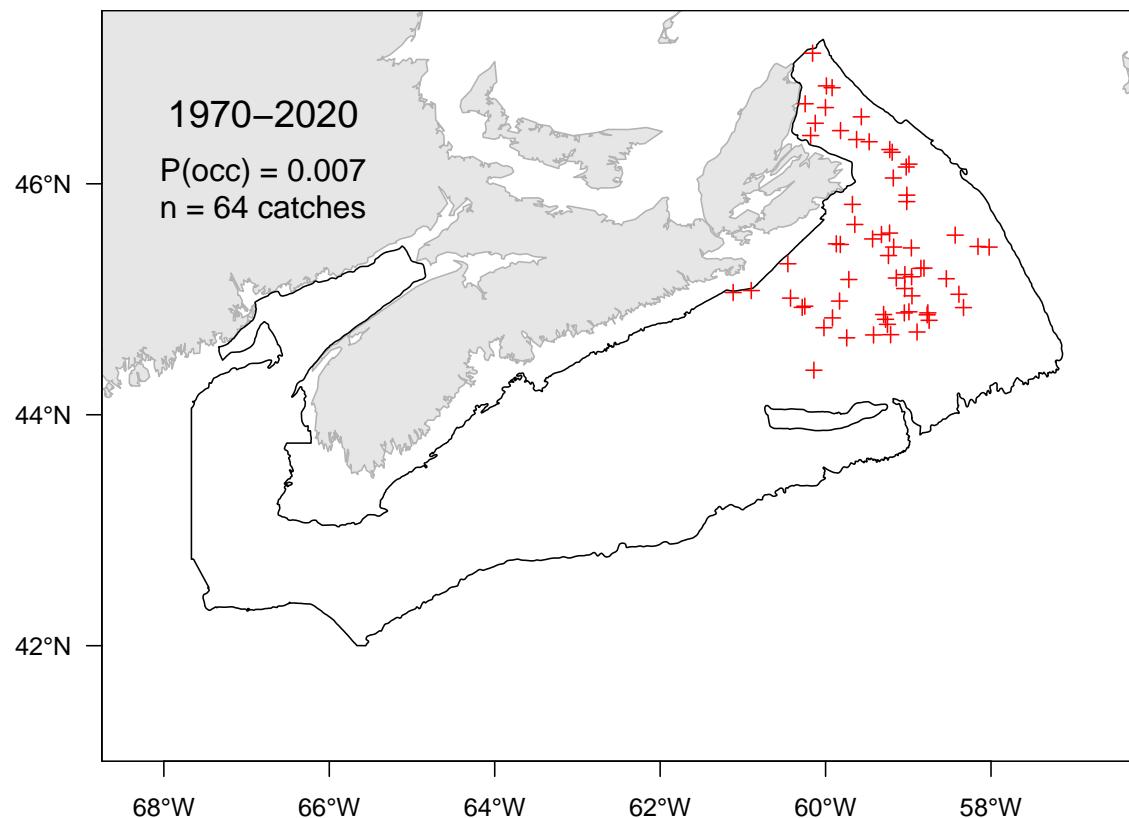


Figure 6.79A. Catch distribution for Newfoundland eelpout.

6.80 Newfoundland eelpout (*Lycodes lavalaei*) - species code 620 (category LR)

Scientific name: [*Lycodes lavalaei*](#)

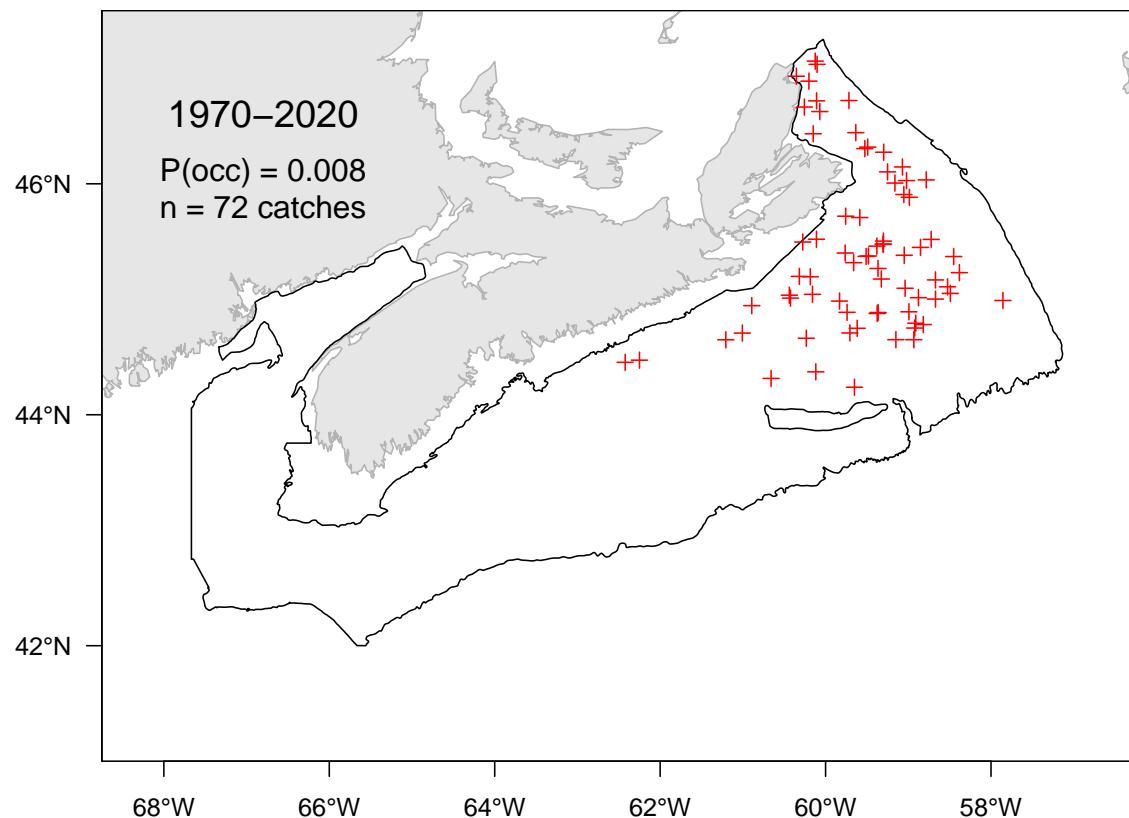


Figure 6.80A. Catch distribution for Newfoundland eelpout.

6.81 Rock gunnel (Sigouine de roche) - species code 621 (category LR)

Scientific name: [Pholis gunnellus](#)

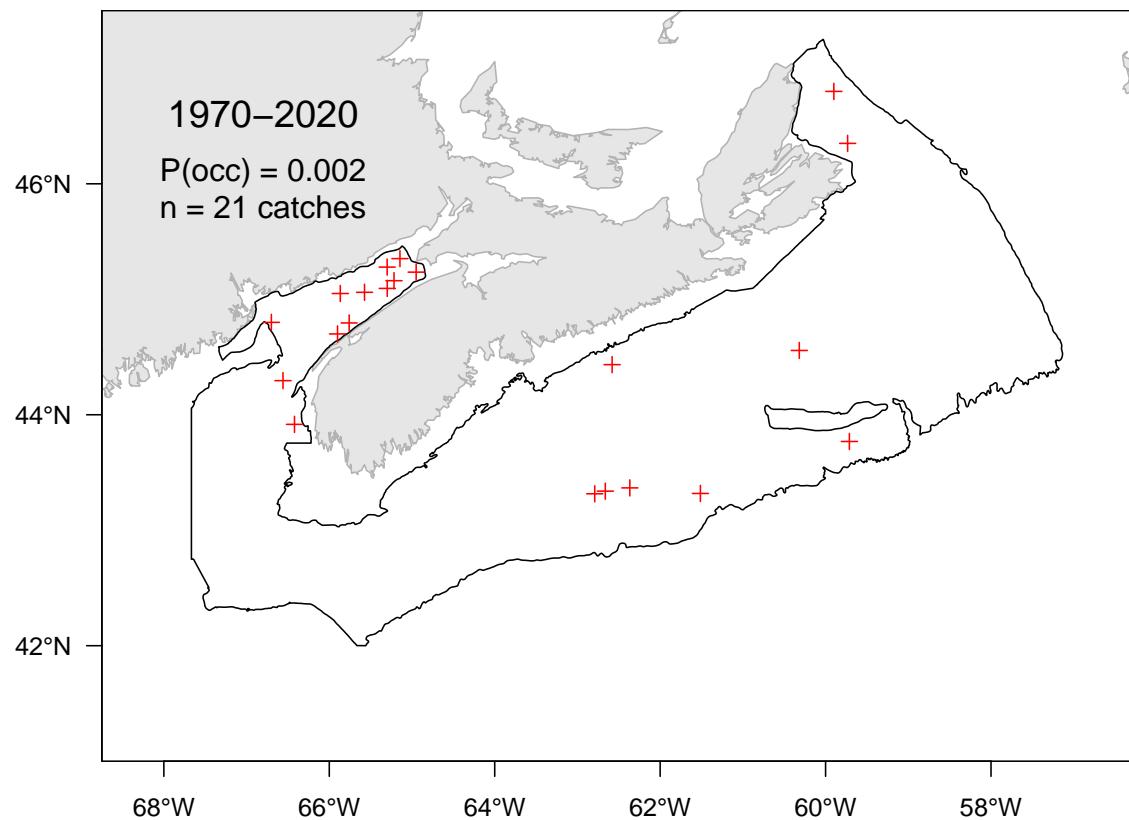


Figure 6.81A. Catch distribution for Rock gunnel.

6.82 Radiated shanny (Ulvaire deux-lignes) - species code 625 (category LR)

Scientific name: [Ulvaria subbifurcata](#)

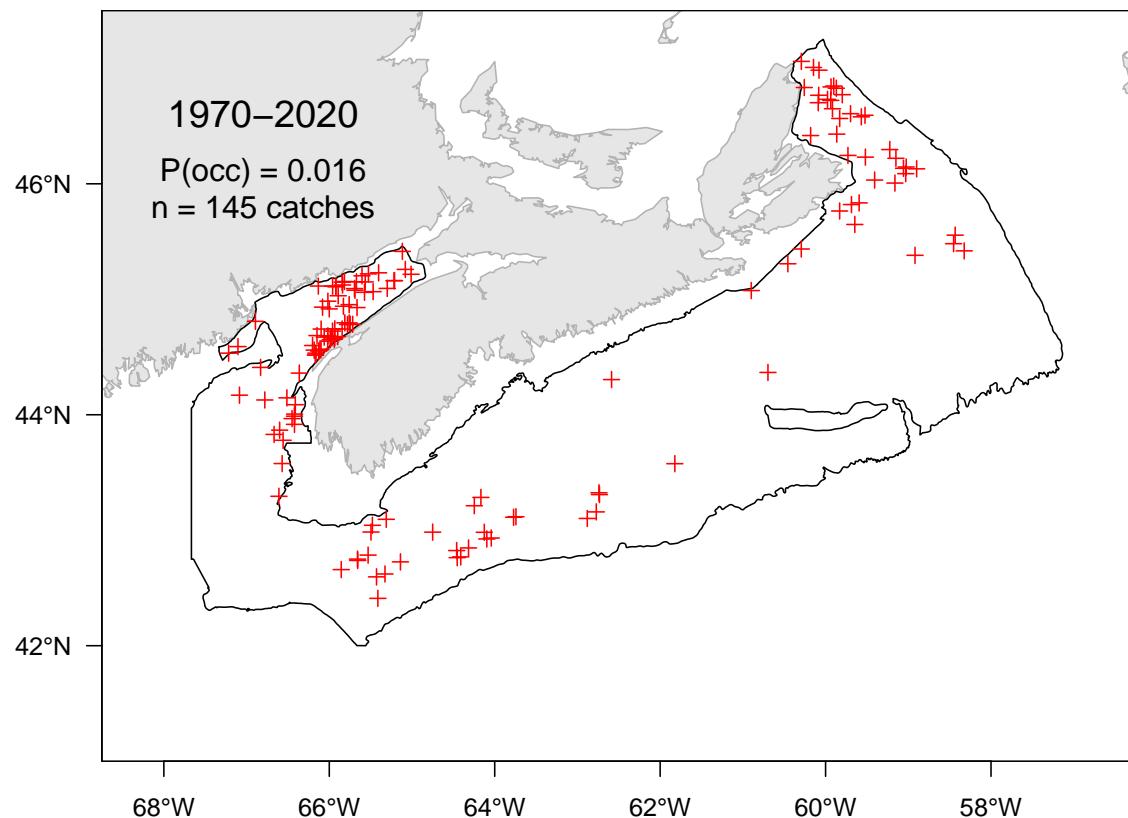


Figure 6.82A. Catch distribution for Radiated shanny.

6.83 Fourline snakeblenny (Quatre-lignes atlantique) - species code 626 (category LR)

Scientific name: [Eumesogrammus praecisus](#)

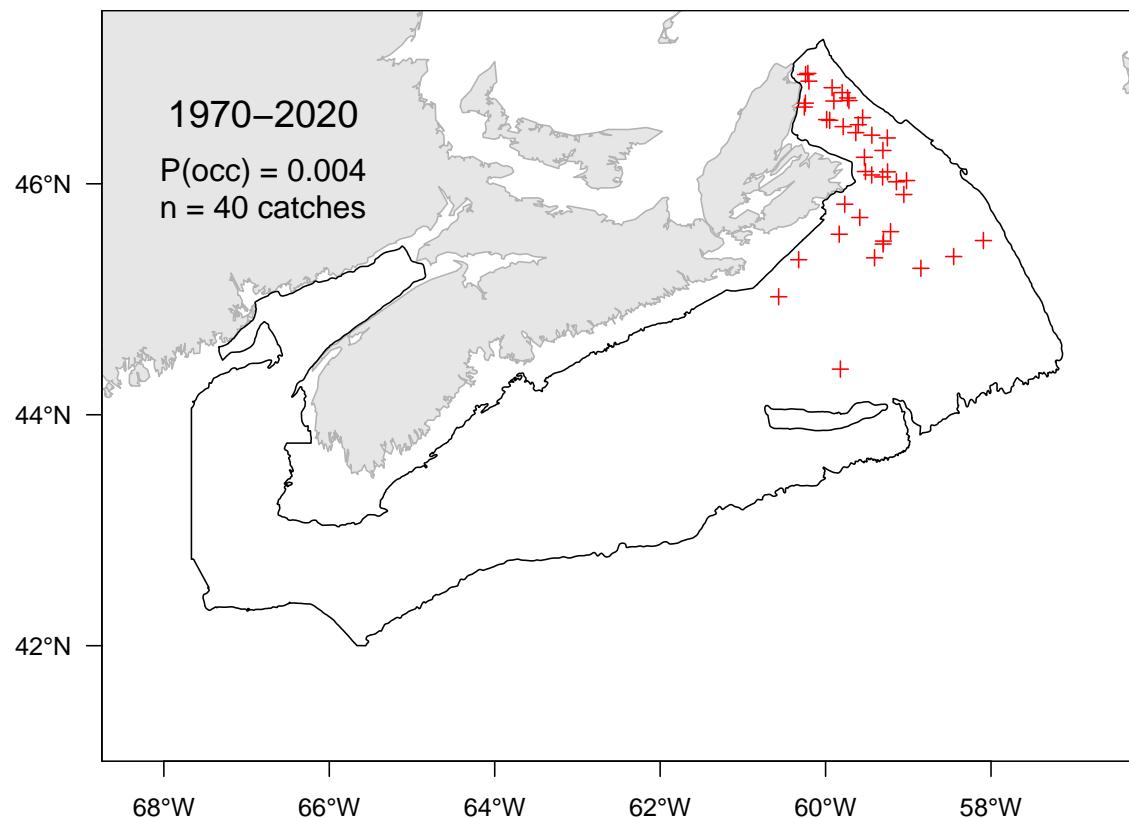


Figure 6.83A. Catch distribution for Fourline snakeblenny.

6.84 Wrymouth (Terrassier tacheté) - species code 630 (category LR)

Scientific name: [Cryptacanthodes maculatus](#)

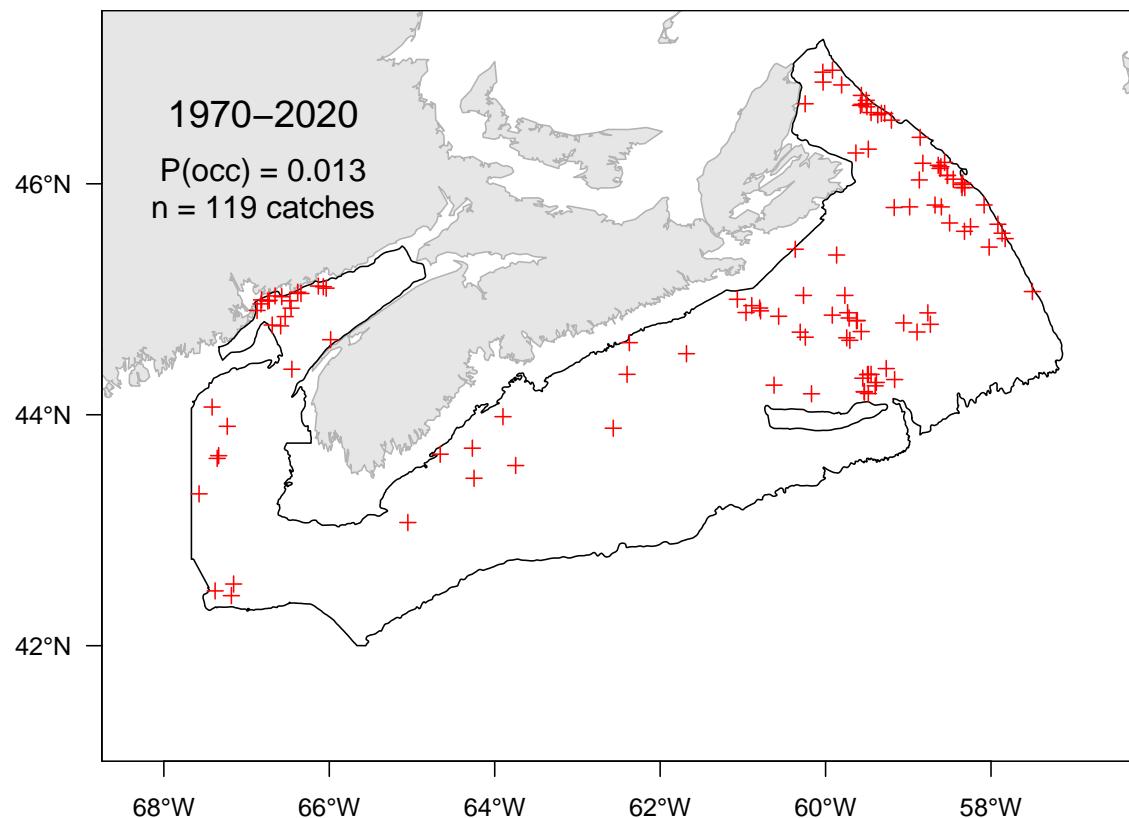


Figure 6.84A. Catch distribution for Wrymouth.

6.85 Arctic eelpout (*Lycodes arctique*) - species code 641 (category LR)

Scientific name: [*Lycodes reticulatus*](#)

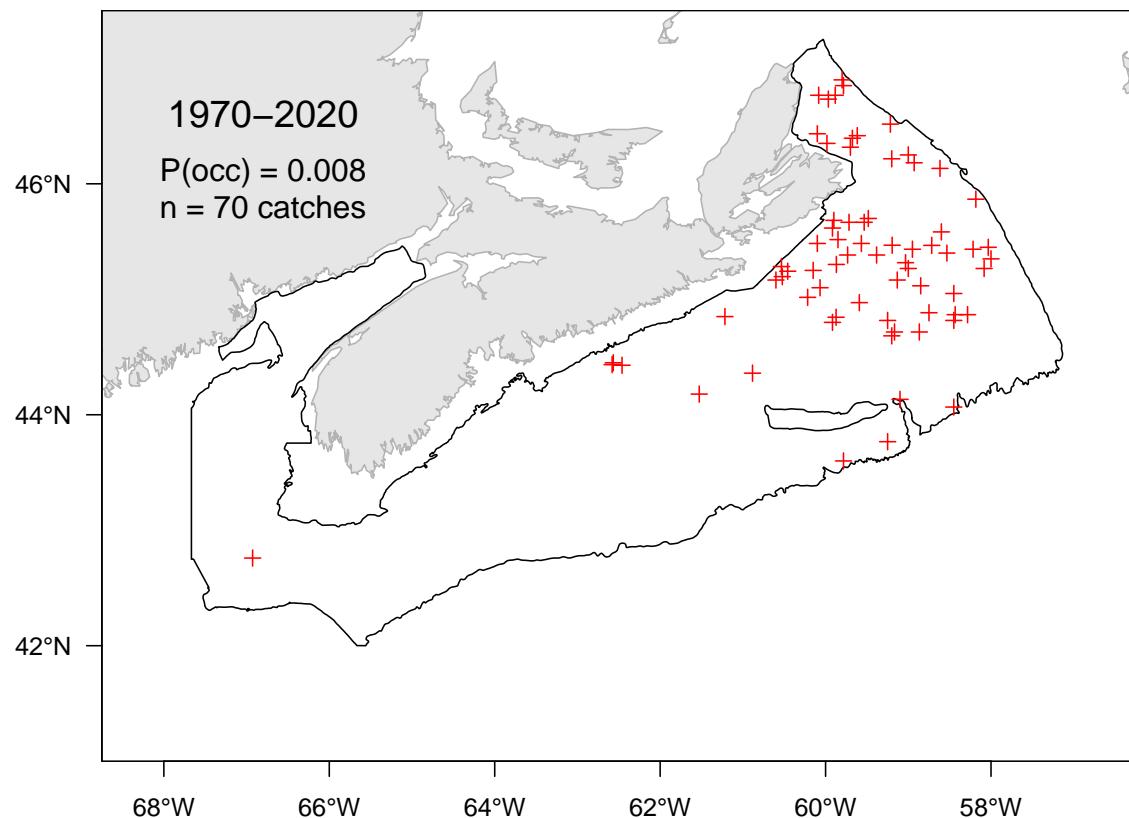


Figure 6.85A. Catch distribution for Arctic eelpout.

6.86 Atlantic soft pout (*Mollasse atlantique*) - species code 646 (category LR)

Scientific name: [*Melanostigma atlanticum*](#)

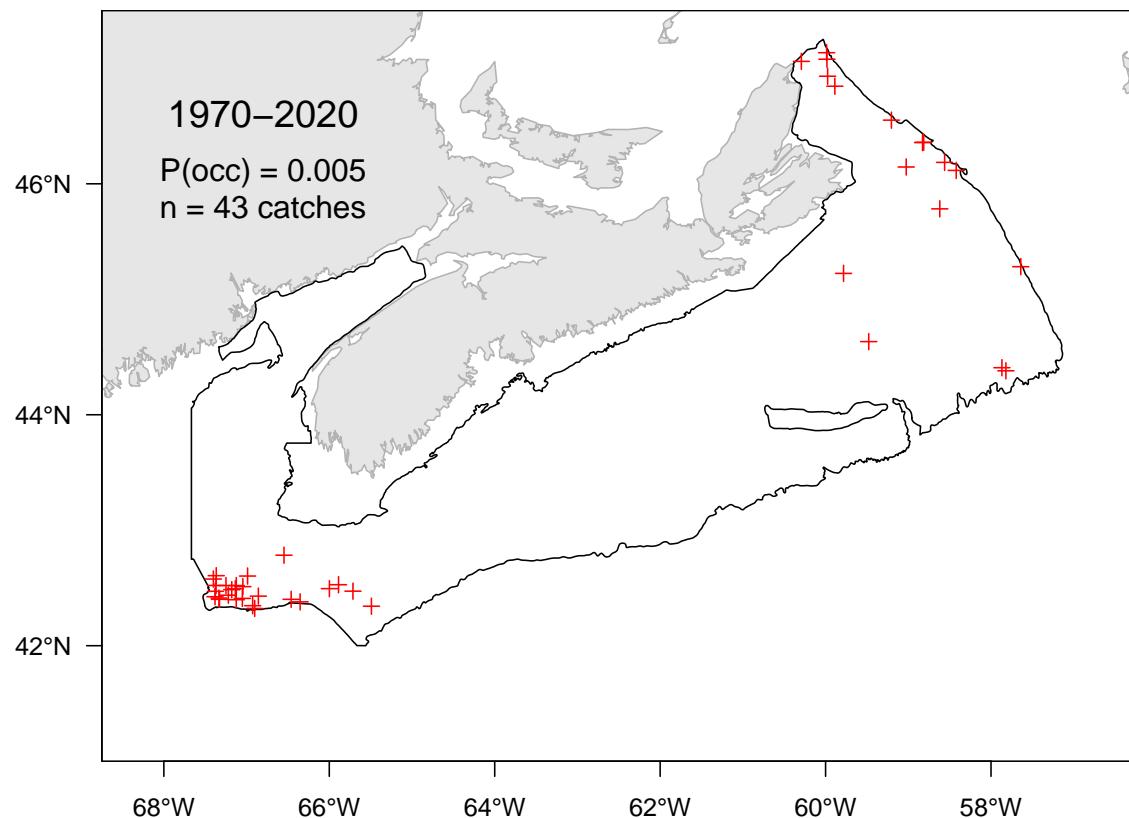


Figure 6.86A. Catch distribution for Atlantic soft pout.

6.87 Rainbow smelt (Éperlan arc-en-ciel) - species code 63 (category LR)

Scientific name: [Osmerus mordax](#)

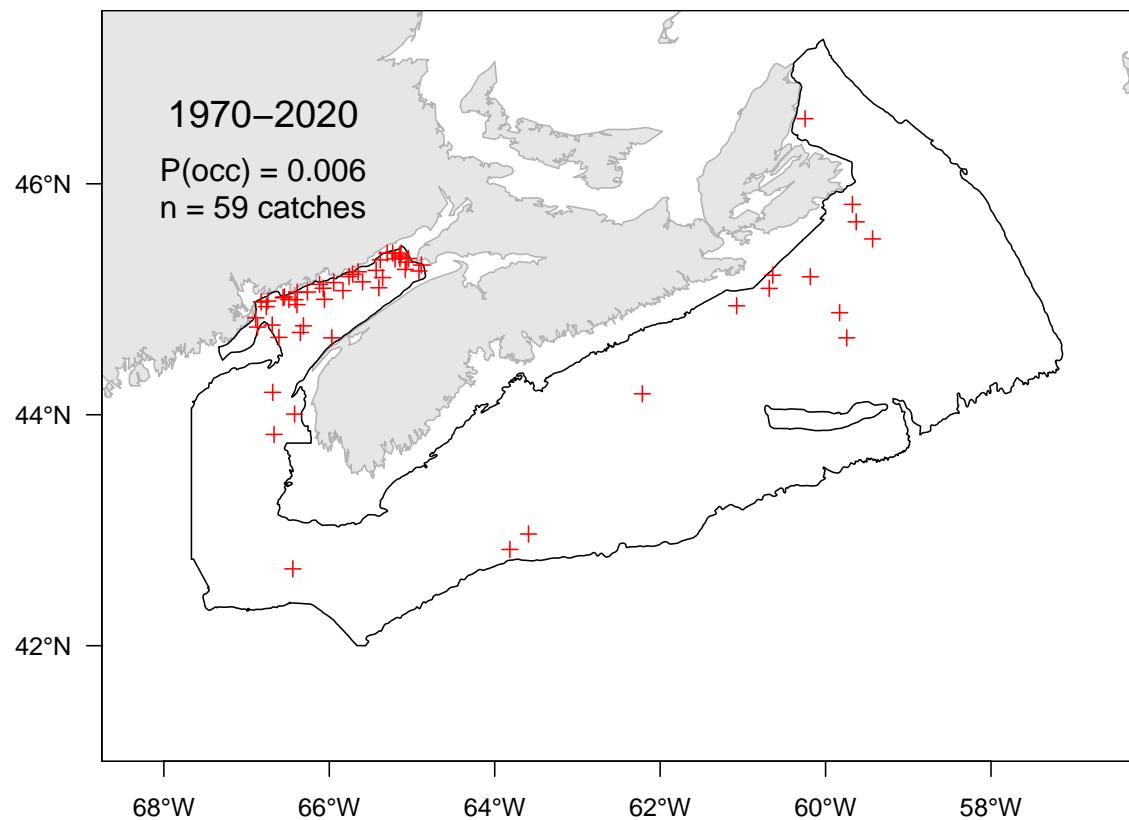


Figure 6.87A. Catch distribution for Rainbow smelt.

6.88 Longnose greeneye (Oeil-vert à long nez) - species code 149 (category LR)

Scientific name: [Parasudis triculenta](#)

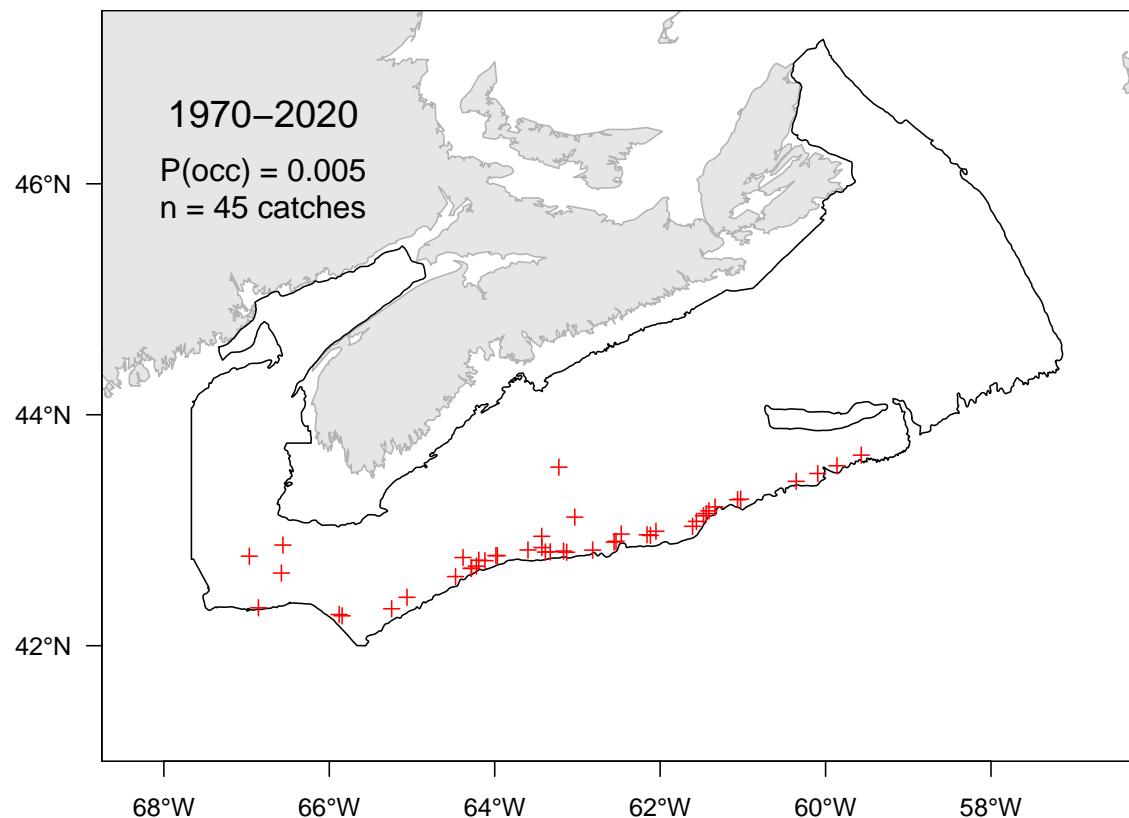


Figure 6.88A. Catch distribution for Longnose greeneye.

6.89 Shortnose greeneye (Éperlan du large) - species code 156 (category LR)

Scientific name: [Chlorophthalmus agassizi](#)

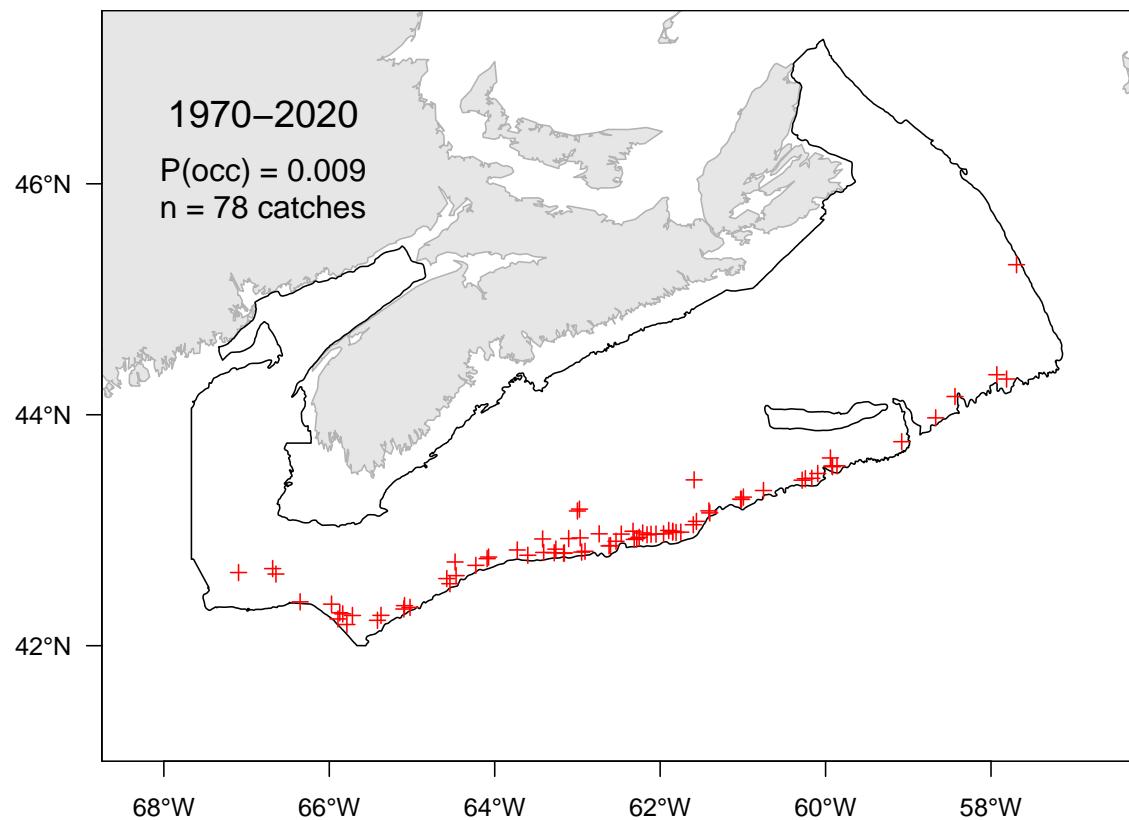


Figure 6.89A. Catch distribution for Shortnose greeneye.

6.90 White barracudina (*Lussion blanc*) - species code 712 (category LR)

Scientific name: [Arctozenus risso](#)

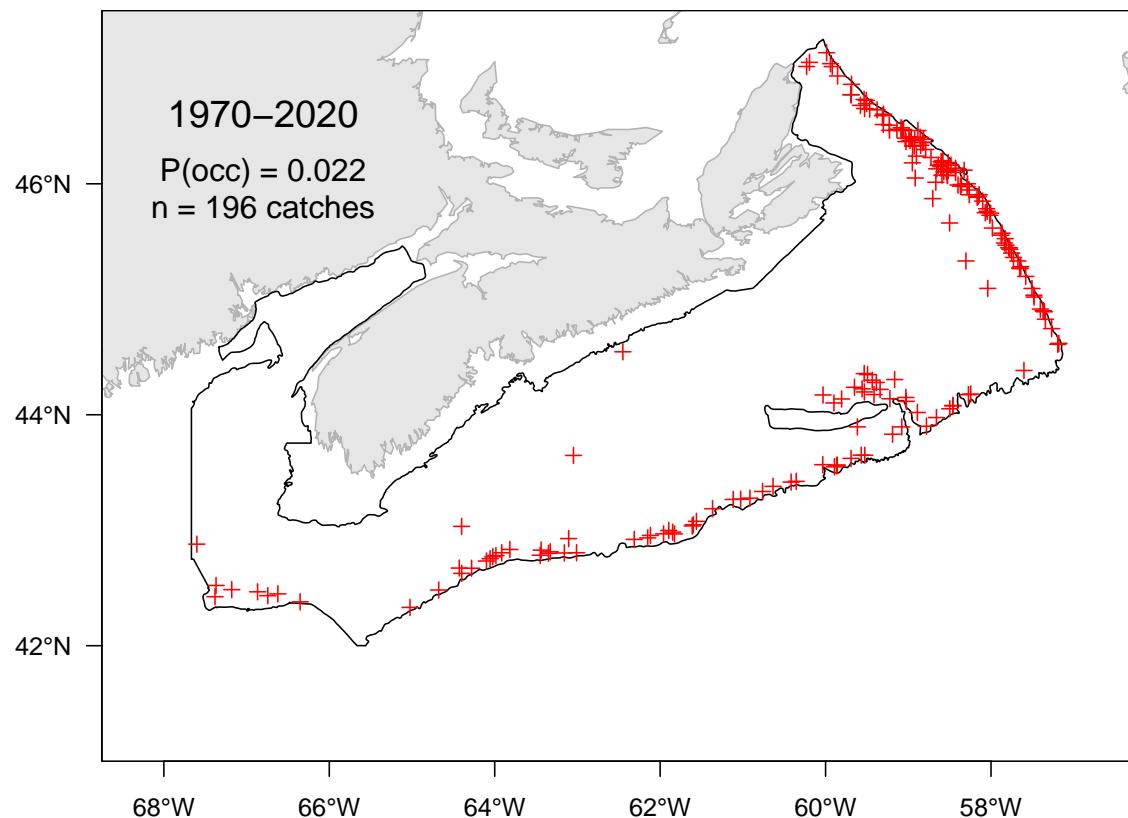


Figure 6.90A. Catch distribution for White barracudina.

6.91 Lanternfishes (Poissons-lanternes) - species code 150 (category LR)

Scientific name: [Myctophidae](#)

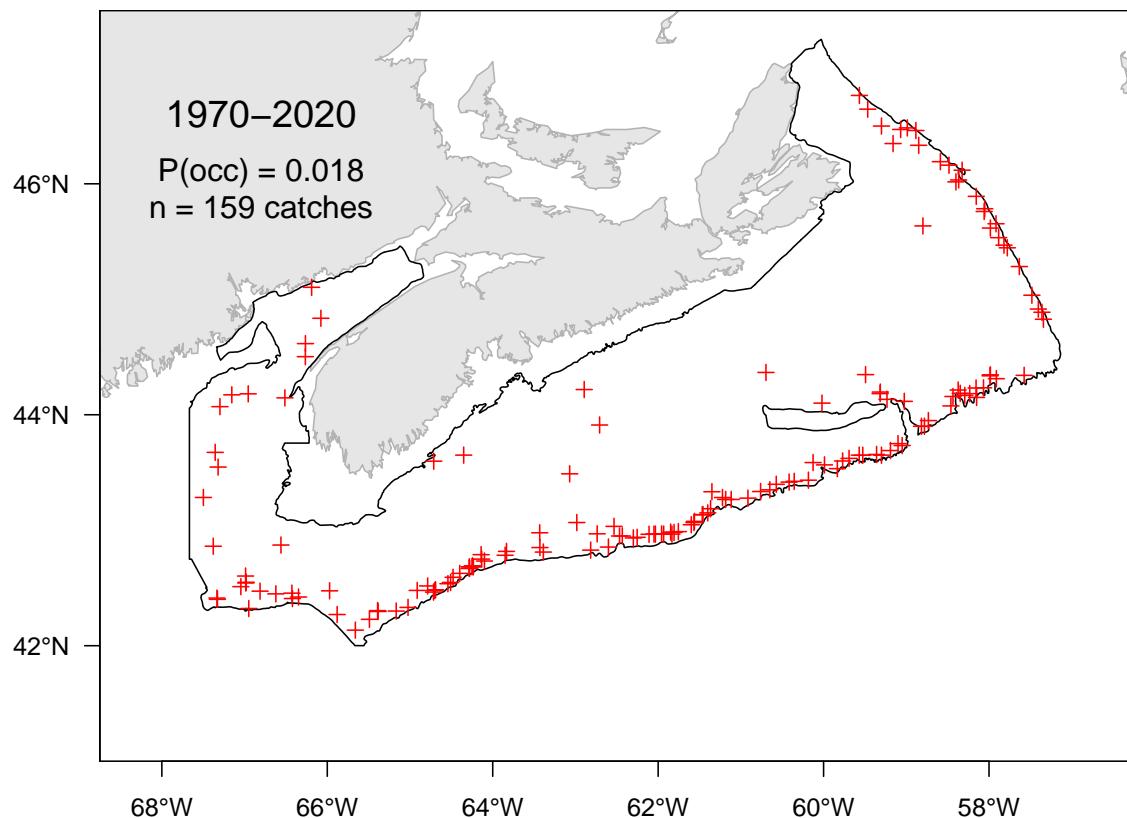


Figure 6.91A. Catch distribution for Lanternfishes.

6.92 Silvery lightfish (Brossé améthyste) - species code 158 (category LR)

Scientific name: [Maurolicus muelleri](#)

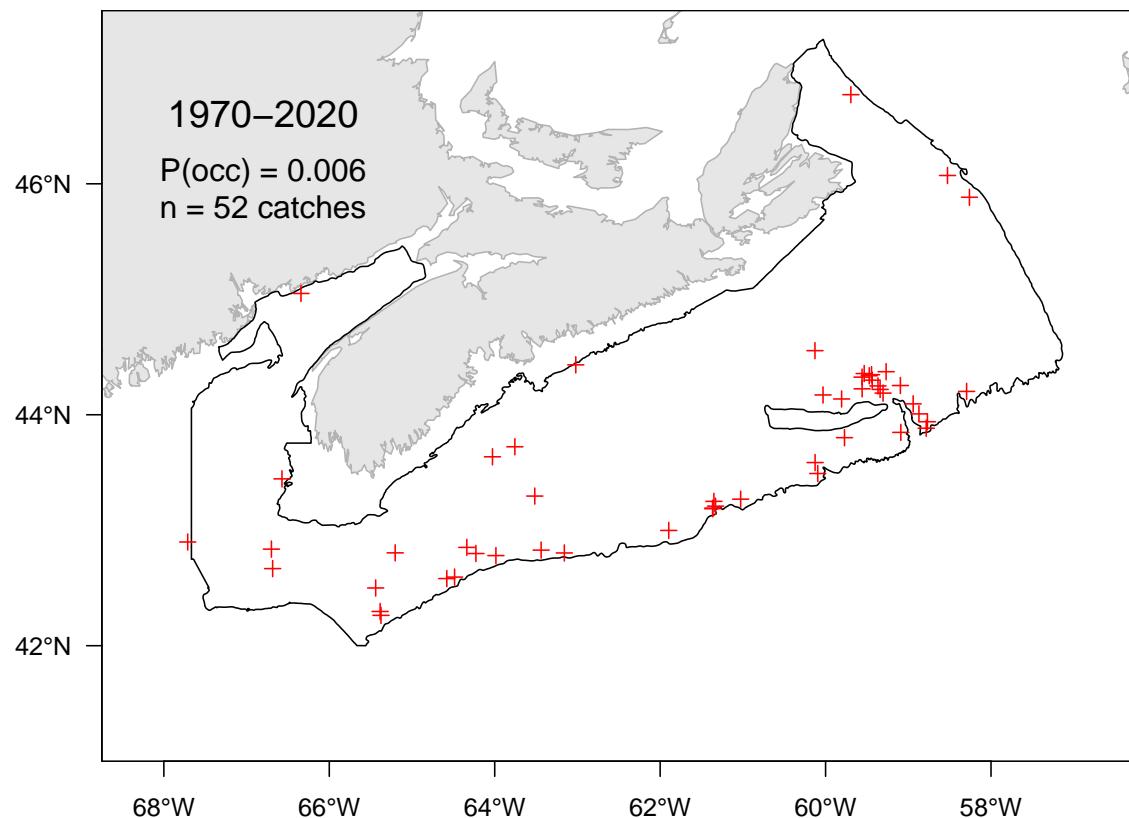


Figure 6.92A. Catch distribution for Silvery lightfish.

6.93 Boa dragonfish (Dragon-boa) - species code 159 (category LR)

Scientific name: [Stomias boa](#)

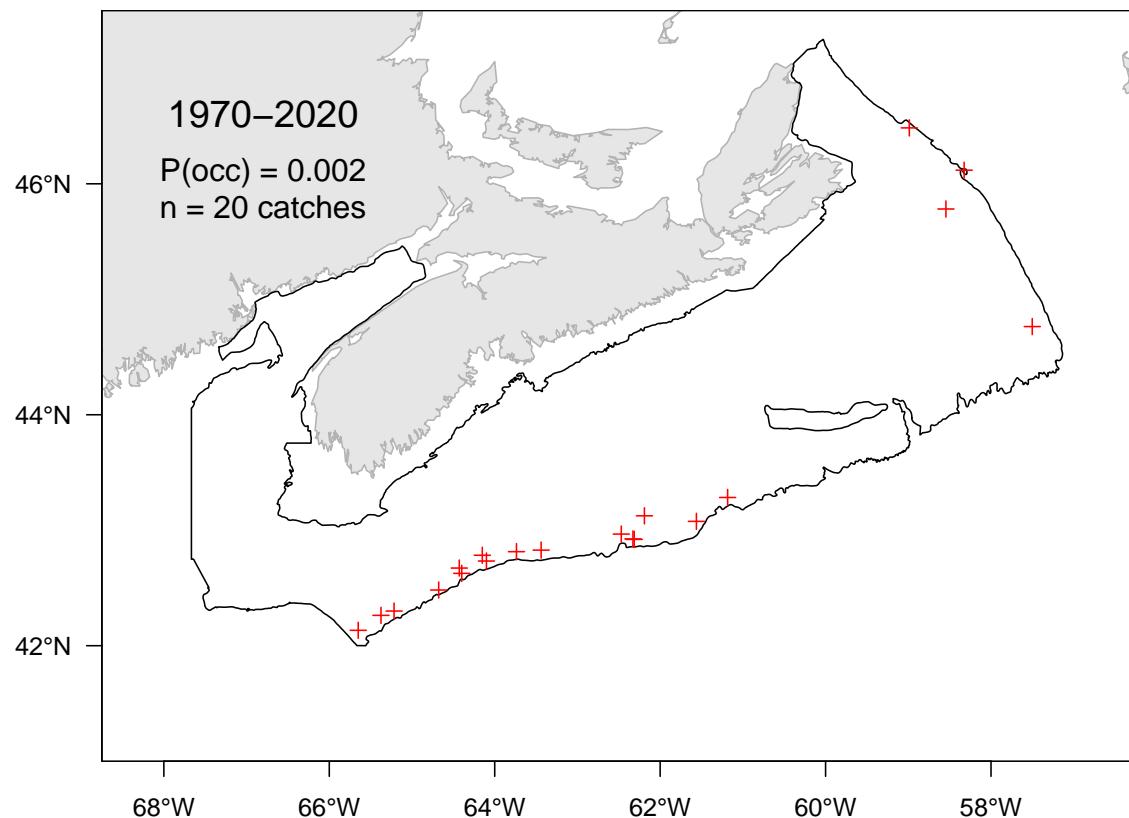


Figure 6.93A. Catch distribution for Boa dragonfish.

6.94 Hatchetfishes (Haches d'argent) - species code 741 (category LR)

Scientific name: [Sternoptychidae](#)

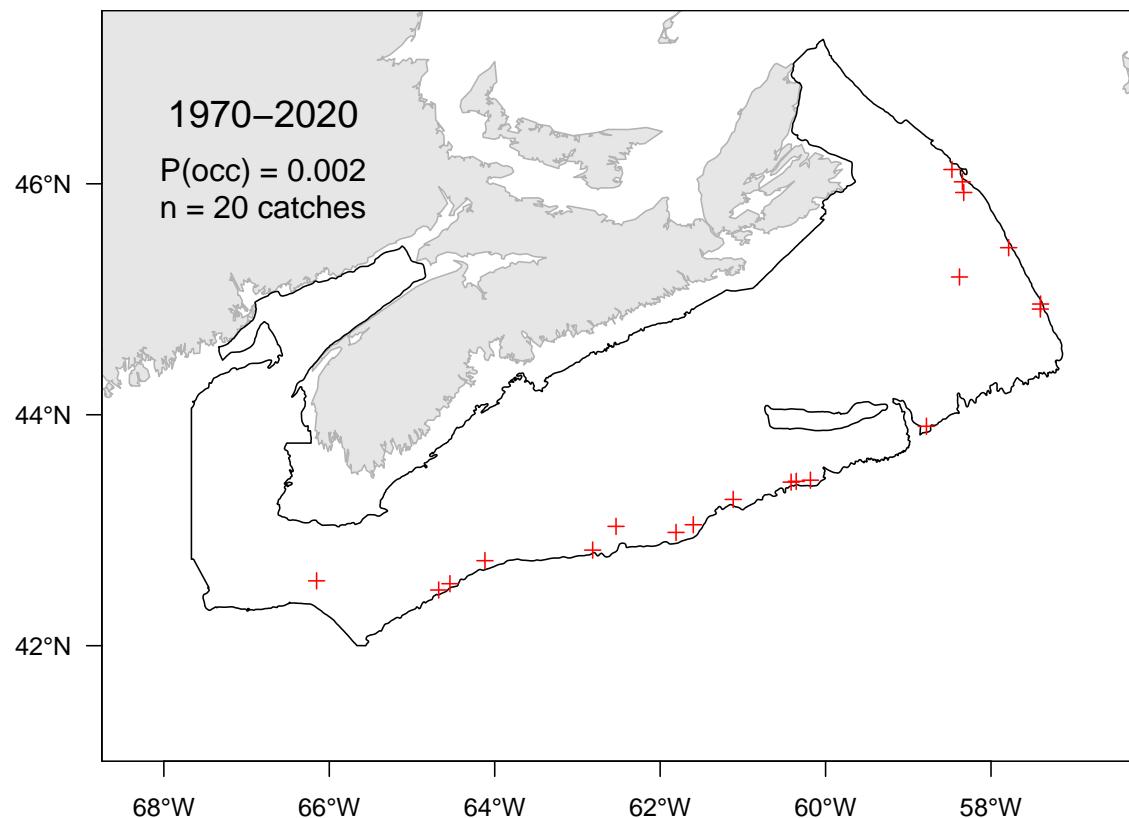


Figure 6.94A. Catch distribution for Hatchetfishes.

6.95 Atlantic batfish (*Malthe atlantique*) - species code 742 (category LR)

Scientific name: [Dibranchus atlanticus](#)

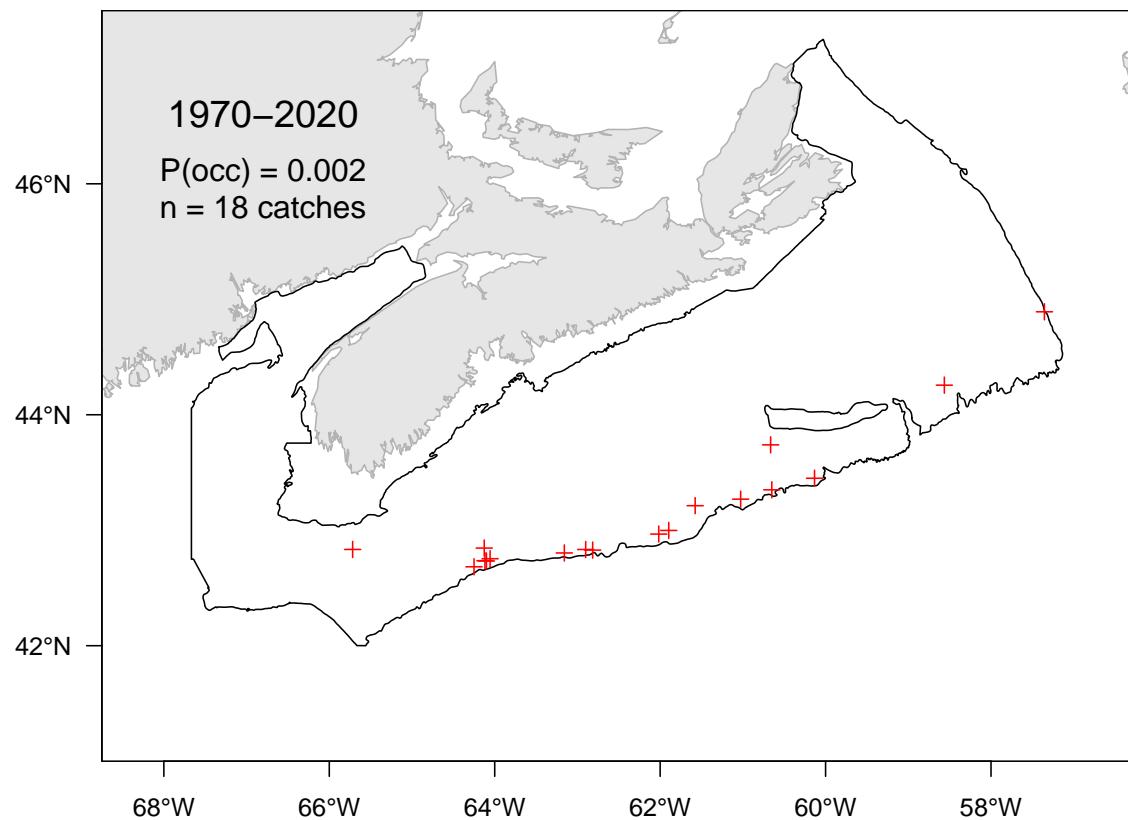


Figure 6.95A. Catch distribution for Atlantic batfish.

6.96 Slender snipe eel (*Avocette ruban*) - species code 604 (category LR)

Scientific name: [Nemichthys scolopaceus](#)

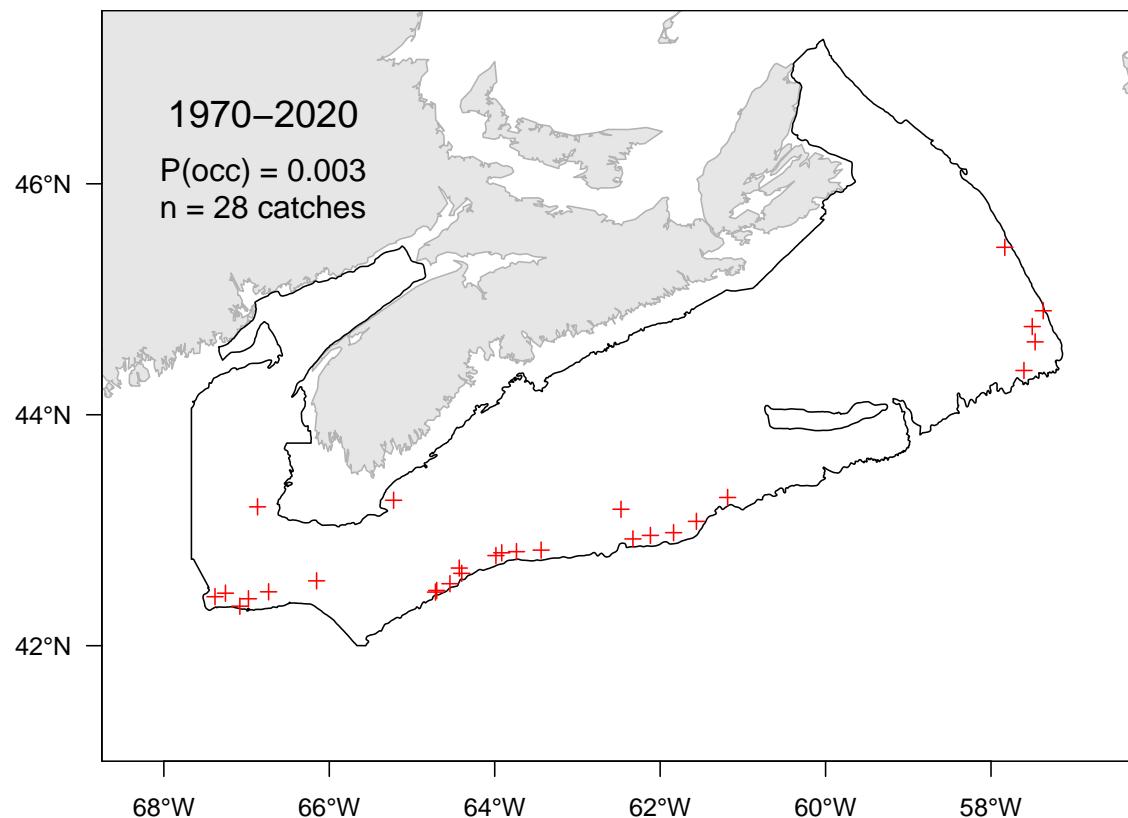


Figure 6.96A. Catch distribution for Slender snipe eel.

6.97 Silvery John dory (Saint Pierre argenté) - species code 704 (category LR)

Scientific name: [Zenopsis conchifer](#)

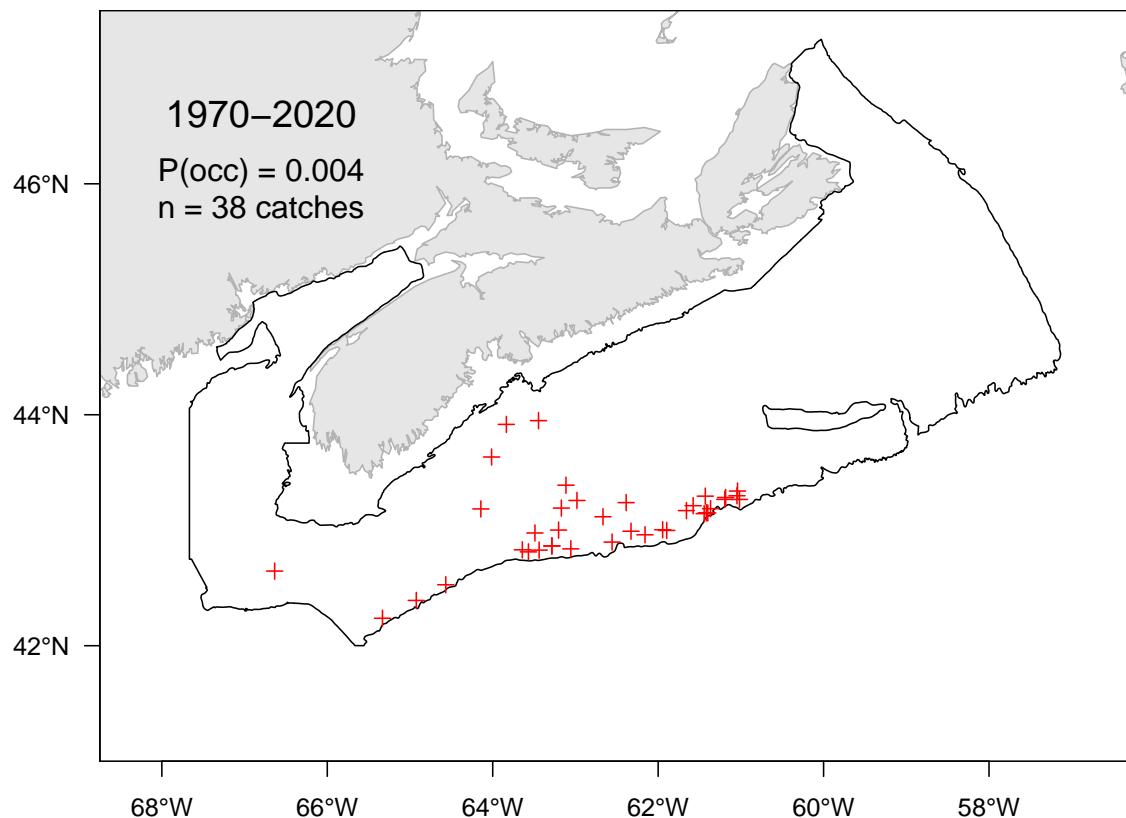


Figure 6.97A. Catch distribution for Silvery John dory.

6.98 Atlantic saury (Balaou atlantique) - species code 720 (category LR)

Scientific name: [Scomberesox saurus](#)

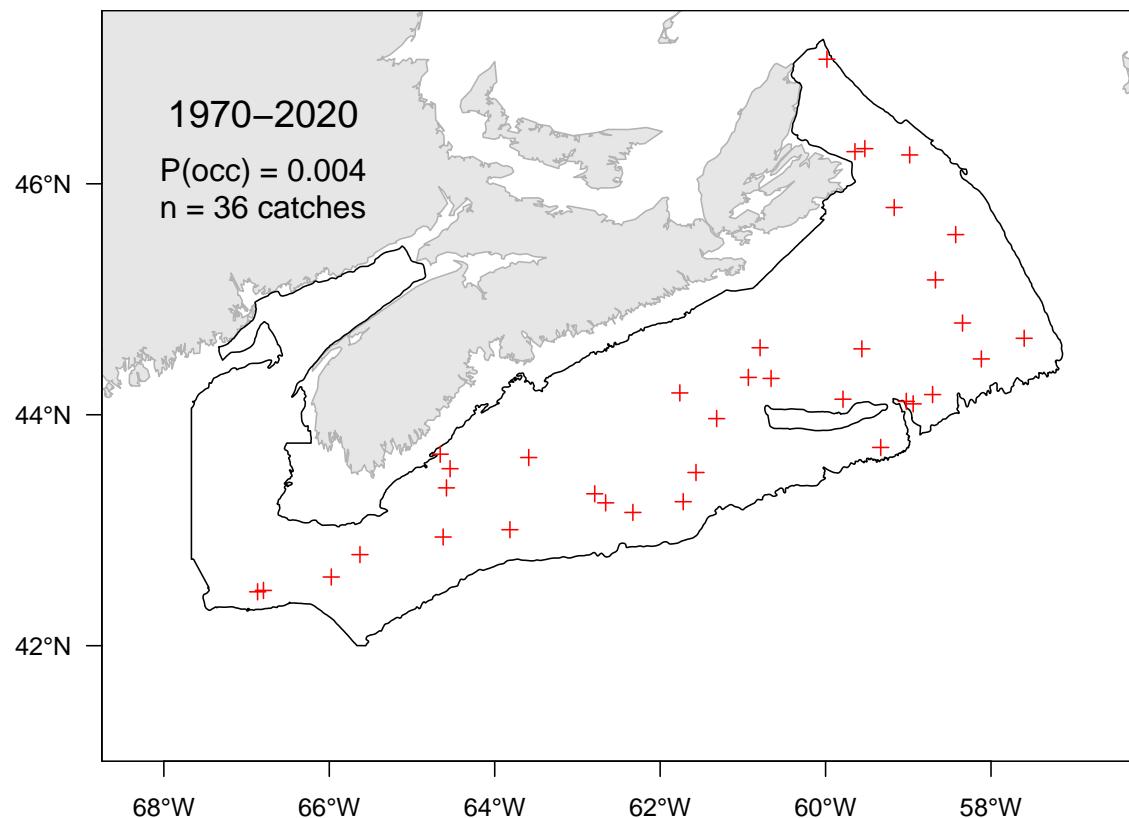


Figure 6.98A. Catch distribution for Atlantic saury.

6.99 Black dogfish (Aiguillat noir) - species code 221 (category LR)

Scientific name: *Centroscyllium fabricii*

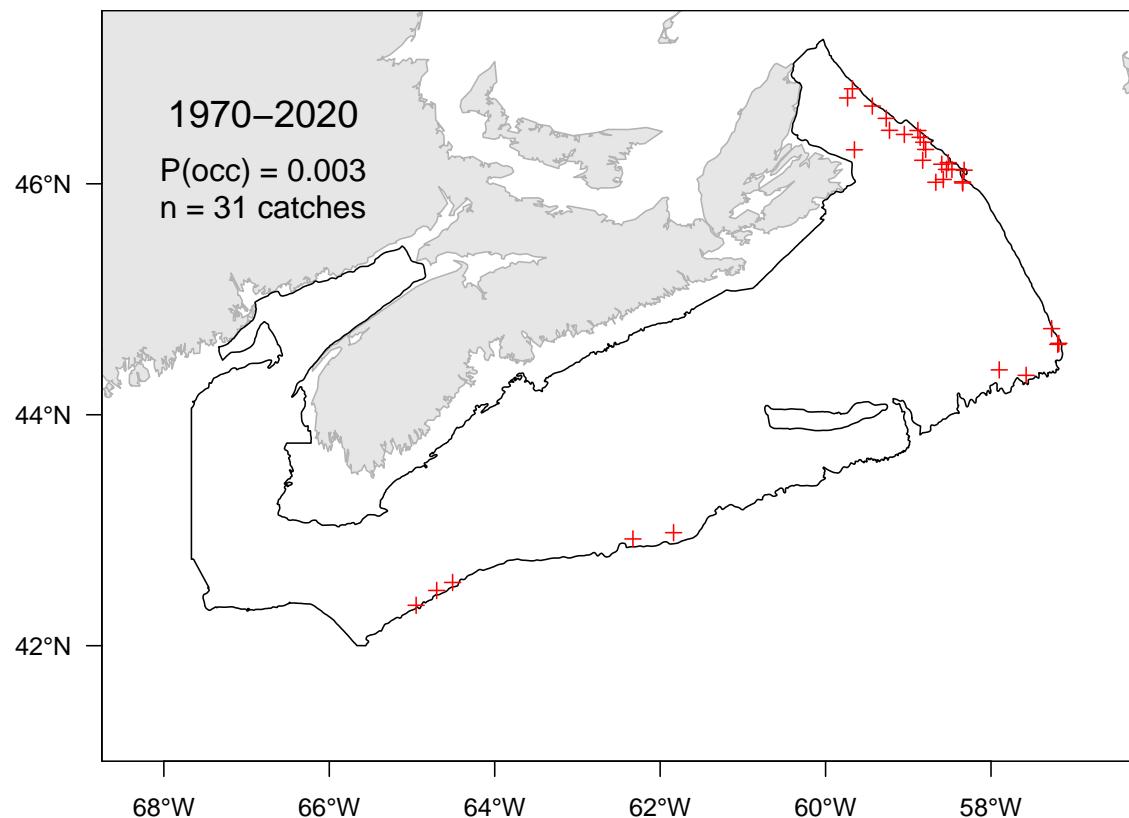


Figure 6.99A. Catch distribution for Black dogfish.

6.100 Longfin inshore squid (Calmar totam) - species code 4512 (category LR)

Scientific name: [Doryteuthis pealeii](#)

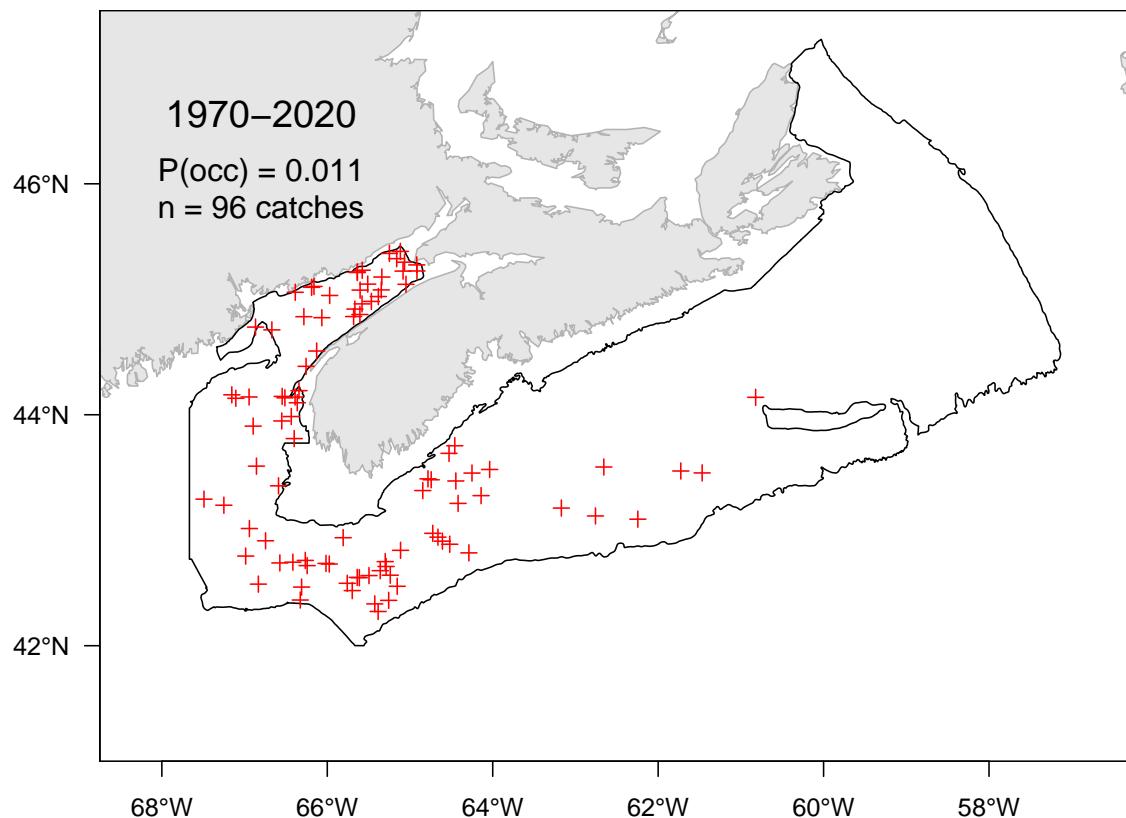


Figure 6.100A. Catch distribution for Longfin inshore squid.

6.101 Red deepsea crab (Crabe rouge) - species code 2532 (category SR)

Scientific name: [Chaceon quinquedens](#)

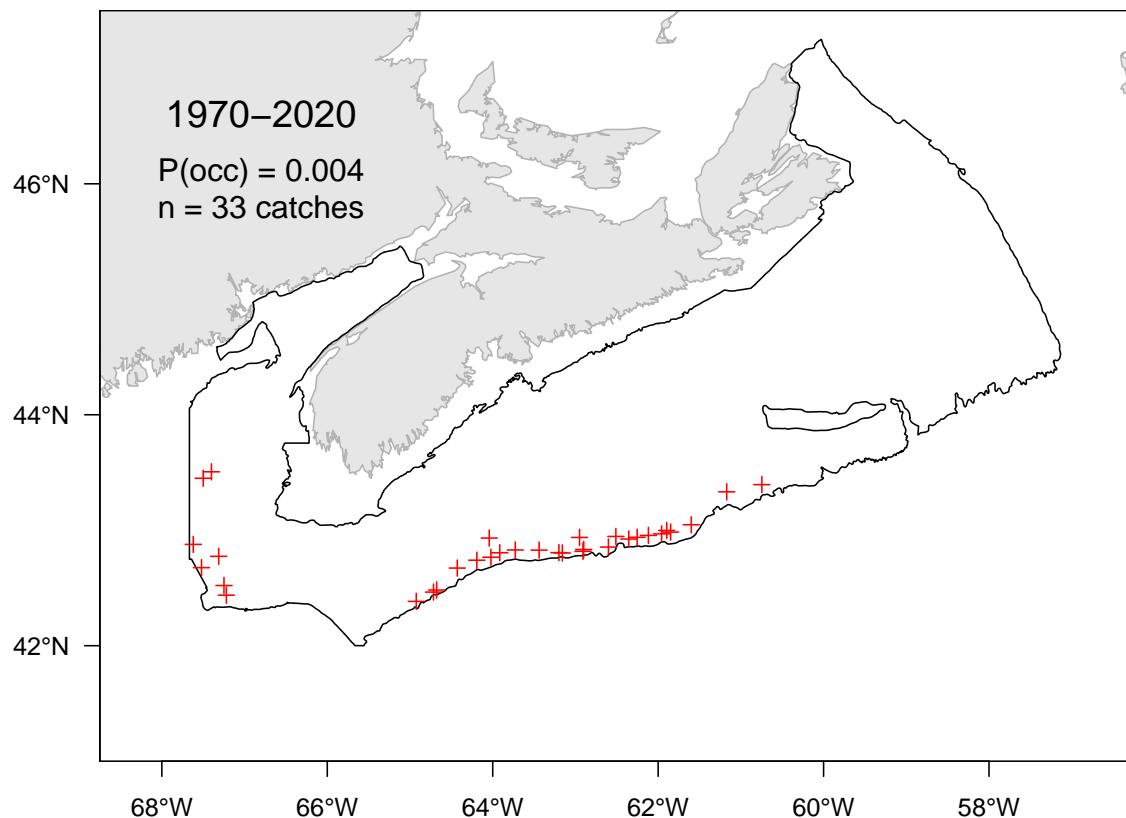


Figure 6.101A. Catch distribution for Red deepsea crab.

6.102 Cunner (Tanche-tautogue) - species code 122 (category LR)

Scientific name: [Tautogolabrus adspersus](#)

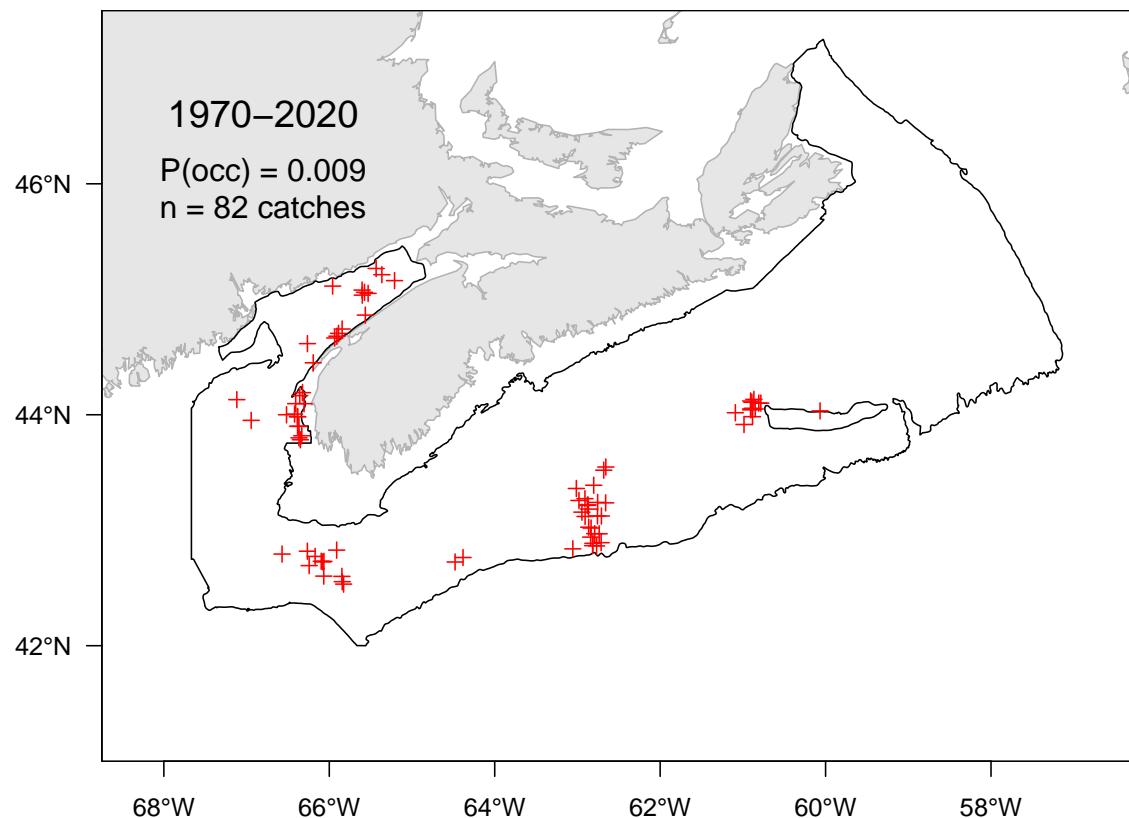


Figure 6.102A. Catch distribution for Cunner.

6.103 Spotfin dragonet (Dragonnet tacheté) - species code 637 (category LR)

Scientific name: [Foetorepus agassizii](#)

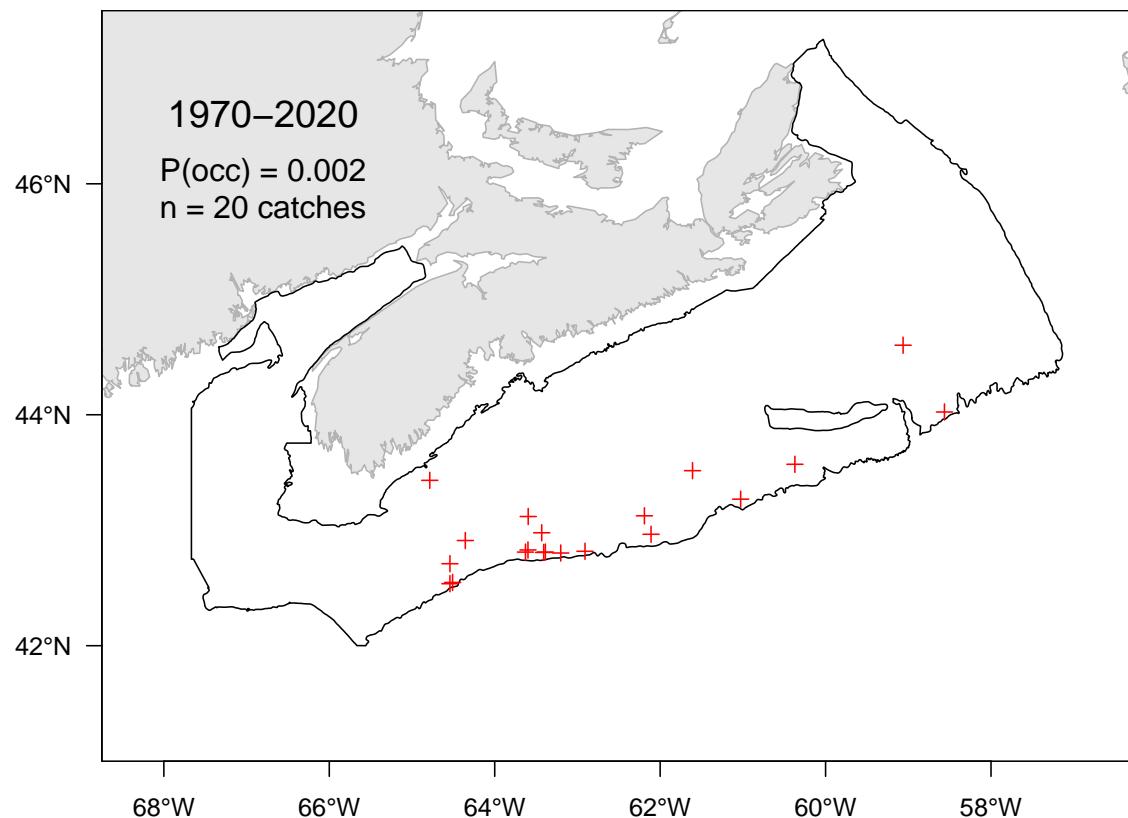


Figure 6.103A. Catch distribution for Spotfin dragonet.

7 References

- Agardy, T., Notarbartolo di Sciara, G., and Christie, P. 2011. [Addressing the shortcomings of marine protected areas through large scale marine spatial planning](#). Marine Policy 35(2): 226–232.
- Anderson, S.C., Grandin, C., Edwards, A.M., Grinnell, M.H., Ricard, D., and Haigh, R. 2021. Csasdown: Reproducible CSAS Reports with Bookdown.
- Anderson, S.C., Keppel, E.A., and Edwards, A.M. 2019. [A reproducible data synopsis for over 100 species of British Columbia groundfish](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2019/041. vii + 321 p.
- Anderson, S.C., Keppel, E.A., and Edwards, A.M. 2020. [Reproducible visualization of raw fisheries data for 113 species improves transparency, assessment efficiency, and monitoring](#). Fisheries 45: 535–543.
- Appeltans, W., Bouchet, P., Boxshall, G.A., De Broyer, C., Voogd, N.J. de, Gordon, D.P., Hoeksema, B.W., Horton, T., Kennedy, M., J., M., Poore, G.C.B., Read, G., Stöhr, S., Walter, T.C., and Costello, M.J. (*Editors*). 2012. World Register of Marine Species. Accessed at <http://www.marinespecies.org> on 2020-12-1.
- Baddeley, R., A. 2015. Spatial Point Patterns: Methodology and Applications with R. Chapman; Hall/CRC Press, London <http://www.crcpress.com/Spatial-Point-Patterns-Methodology-and-Applications-with-R/Baddeley-Rubak-Turner/9781482210200/>.
- Benoît, H.P., Abgrall, M.-J., and Swain, D.P. 2003. [An assessment of the general status of marine and diadromous fish species in the southern Gulf of St. Lawrence based on annual bottom trawl surveys \(1971-2002\)](#). Can. Tech. Rep. Fish. Aquat. Sci. 2472: iv + 183 p.
- Bivand, R. 2020. classInt: Choose univariate class intervals. R package version 0.4-3 <https://CRAN.R-project.org/package=classInt>.
- Bivand, R., and Lewin-Koh, N. 2020. Maptools: Tools for handling spatial objects. R package version 1.0-2 <https://CRAN.R-project.org/package=maptools>.
- Bivand, R., and Rundel, C. 2020. Rgeos: Interface to geometry engine - open source ('GEOS'). R package version 0.5-5 <http://CRAN.R-project.org/package=rgeos>.
- Boudreau, S.A., Shackell, N.L., Carson, S., and Heyer C. E., den. 2017. [Connectivity, persistence, and loss of high abundance areas of a recovering marine fish population in the Northwest Atlantic Ocean](#). Ecol. Evol. 7: 9739–9749.
- Bourdages, H., and Ouellet, J.-F. 2012. [Geographic distribution and abundance indices of marine fish in the northern Gulf of St. Lawrence \(1990-2009\)](#). Can. Tech. Rep. Fish. Aquat. Sci. 2963: vi + 171 p.
- Brown, C., Sameoto, J., and Smith, S.J. 2012. [Multiple methods, maps, and management applications: Purpose made seafloor maps in support of ocean management](#). Journal of Sea research 72: 113.

- Bundy, A., Will, E., Serdynska, A., Cook, A., and Ward-Paige, C.A. 2017. [Defining and mapping functional groups for fishes and invertebrates in the Scotian Shelf bioregion](#). Can. Tech. Rep. Fish. Aquat. Sci. 3186: iv + 49 p.
- Clark, D.W., and Emberley, J. 2011. Update of the 2010 Summer Scotian Shelf and Bay of Fundy Research Vessel Survey. Can. Tech. Rep. Fish. Aquat. Sci.: 1238: ix + 98 p.
- Cook, A.M., Cassista Da-Ros, M., and Denton, C. 2017. [Framework Assessment of the Offshore American Lobster in Lobster Fishing Area \(LFA\) 41.](#) DFO Can. Sci. Advis. Sec. Res. Doc. 2017/065 viii + 186 p.
- DFO. 2016. DFO Maritimes Research Vessel Trawl Surveys Invertebrate observations. Version 7 In OBIS Canada Digital Collections. Bedford Institute of Oceanography, Dartmouth, NS, Canada, Published by OBIS, Digital 2016.
- DFO. 2021. Maritimes research vessel surveys [Dataset]. Retrieved from <https://open.canada.ca/data/en/dataset/8ddcaeeaa-b806-4958-a79f-ba9ab645f53b>.
- Doubleday, W.G., and Rivard, D. 1981. Bottom trawl surveys. Can. Spec. Publ. Fish. Aquat. Sci: 58: 237 pp.
- Ehler, C., and Douvere, F. 2009. Marine spatial planning: A step-by-step approach.
- Fanning, L.P. 1985. [Intercalibration of Research Survey Results Obtained by Different Vessels](#). CAFSAC Research Document 85/3.
- Fanning, P. 1984. Preliminary Analysis of Alfred Needler - Lady Hammond Comparative Fishing Experiments (Silver Hake, 1983). NAFO SCR Doc. 84/VI/82.
- Fowler, G.M., and Showell, M.A. 2009. Calibration of bottom trawl survey vessels: Comparative fishing between the Alfred Needler and teleost on the Scotian Shelf during the summer of 2005. Can. Tech. Rep. Fish. Aquat. Sci. 2824: iv + 25 p.
- French, K., Shackell, N., and Heyer, N. den. 2018. [Information on the Potential for Recovery of Cusk in Canadian Waters](#). Fish. Bull. 116: 107–121.
- Greenan, B.J.W., Shackell, N.L., Ferguson, K., Greyson, P., Cogswell, A., Brickman, D., Wang, Z., Cook, A., Brennan, C.E., and Saba, V.S. 2019. Climate Change Vulnerability of American Lobster Fishing Communities in Atlantic Canada. Frontiers in Marine Science 6: 579.
- Harris, L.E., Greenlaw, M., McCurdy, D., and MacDonald, D. 2018. [Information on the Potential for Recovery of Cusk in Canadian Waters](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2018/002. vi + 62 p.
- Holstein, J. 2018. Worms: Retrieving Aphia Information from World Register of Marine Species. R package version 0.2.2 <https://CRAN.R-project.org/package=worms>.
- Horsman, T.L., and Shackell, N.L. 2009. [Atlas of important habitat for key fish species of the Scotian Shelf, Canada](#). Can. Tech. Rep. Fish. Aquat. Sci. 2835: viii + 82 p.
- Hubley, P.B., Reeves, A., Smith, S.J., and Nasmith, L. 2014. [Georges Bank 'a' and Browns Bank 'North' Scallop \(*Placopecten magellanicus*\) Stock Assessment](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/079. vi + 58 p.

- Kenchington, E., Callery, O., Davidson, F., Grehan, A., Morato, T., Appiott, J., Davis, A., Dunstan, P., Du Preez, C., Finney, J., González-Irusta, J.M., Howell, K., Knudby, A., Lacharité, M., Lee, J., Murillo, F.J., Beazley, L., Roberts, J.M., Roberts, M., Rooper, C., Rowden, A., Rubidge, E., Stanley, R., Stirling, D., Tanaka, K.R., Vanhatalo, J., Weigel, B., Woolley, S., and Yesson, C. 2019. [Use of Species Distribution Modeling in the Deep Sea](#). Can. Tech. Rep. Fish. Aquat. Sci. 3296: ix + 76 p.
- Kenchington, T.J., and Kenchington, E.L.R. 2017. [Biodiversity metrics for use in the ecosystem approach to oceans management](#). Can. Tech. Rep. Fish. Aquat. Sci. 3186: iv + 49 p.
- Koeller, P., and Smith, S.J. 1983. Preliminary analysis of A.T. Cameron - Lady Hammond comparative fishing experiments 1979-1981. CAFSAC Research Document 83/59.
- Le Cren, E. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecology: 201–219. JSTOR.
- Lohr, S. 1999. Sampling: Design and Analysis. Pacific Grove, CA: Brooks/Cole Publishing Company.
- Losier, R.J., and Waite, L.E. 1989. Systematic listing of scientific and/or common names of invertebrates and marine plants and their respective codes used by marine fish division, Fisheries and Oceans, Scotia-Fundy Region. Canadian Data Report of Fisheries and Aquatic Sciences (721).
- Lowen, B., Hart, D., Stanley, R., Lehnert, S., Bradbury, I., and C., D. 2019. [Assessing effects of genetic, environmental, and biotic gradients in species distribution modelling](#). ICES Journal of Marine Science 76(6): 1762–1775.
- Maginley, C., Collin, B., and Barrie, R. 2014. The Canadian Coast Guard fleet, 1962-2012. Long Hill Publishing, Mahone Bay, Nova Scotia.
- Myers, R.A., and Stokes, K. 1989. Density-dependent habitat utilization of groundfish and the improvement of research surveys. (D:15). International Council for the Exploration of the Sea Council Meeting.
- Nepin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. and. 2019. [Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.
- Neuwirth, E. 2014. RColorBrewer:ColorBrewer palettes. R package version 1.1-2 <https://CRAN.R-project.org/package=RColorBrewer>.
- Pebesma, E. 2004. Multivariable geostatistics in S: The gstat package. In Computers and Geosciences.
- Perry, R.I., and Smith, S.J. 1994. Identifying Habitat Associations of Marine Fishes Using Survey Data: An Application to the Northwest Atlantic. Canadian Journal of Fisheries and Aquatic Sciences (51 (3)): 589–602.
- R Core Team. 2021. [R: A language and environment for statistical computing](#). R Foundation for Statistical Computing, Vienna, Austria.

- Ricard, D., and Gomez, C. 2022. Maritimes-SUMMER-Atlas GitHub repository. <https://github.com/dfo-gulf-science/Maritimes-SUMMER-Atlas>.
- Ricard, D., and Shackell, N.L. 2013. [Population status \(abundance/biomass, geographic extent, body size and condition\), important habitat, depth, temperature and salinity of marine fish and invertebrates on the Scotian Shelf and Bay of Fundy \(1970-2012\)](#). Can. Tech. Rep. Fish. Aquat. Sci. 3012: viii + 180 p.
- Ripley, B., and Lapsley, M. 2019. RODBC: ODBC database access. R package version 1.3-16 <http://CRAN.R-project.org/package=RODBC>.
- Ripley, B., Venables, B., Bates, D., Hornik, K., Gebhardt, A., and Firth, D. 2020. Modern applied statistics with s. R package version 7.3-53 <https://cran.r-project.org/web/packages/MASS/index.html>.
- Robinson, N.M., Nelson, W.A., Costello, M.J., Sutherland, J.E., and Lundquist, C.J. 2017. Systematic review of marine-based species distribution models (SDMs) with recommendations for best practice. Front. Mar. Sci (4): 421.
- Schnute, J.T., Boers, N., and Haigh, R. 2019. PBSmapping: Mapping fisheries data and spatial analysis tools. R package version 2.72.1 <https://cran.r-project.org/web/packages/PBSmapping/index.html>.
- Serdynska, A.R., Gary S. Pardy, and King, M.C. 2021. Offshore Ecological and Human Use Information considered in Marine Protected Area Network Design in the Scotian Shelf Bioregion. Can. Tech. Rep. Fish. Aquat. Sci. 3382: xi + 100 p.
- Shackell, N., Brickman, D., and Frank, K. 2013. [Reserve site selection for data-poor invertebrate fisheries using patch scale and dispersal dynamics: A case study of sea cucumber](#). Aquatic Conserv: Mar. Freshw. Ecosyst. 23: 723–731.
- Simon, J.E., and Comeau, P.A. 1994. [Summer distribution and abundance trends of species caught on the Scotian Shelf from 1970-92, by the research vessel groundfish survey](#). Can. Tech. Rep. Fish. Aquat. Sci. 1953.
- Smith, C.D., Serdynska, A.R., King, M.C., and Shackell, N.L. 2015. [Spring, summer and fall distribution of common demersal fishes on the Scotian Shelf between 1978 and 1985](#). Can. Tech. Rep. Fish. Aquat. Sci. 3068: vi + 38 p.
- Smith, S.J. 1996. Assessment of groundfish stocks based on bottom trawl survey results. NAFO Scientific Council Studies 28: 25–53.
- Smith, S.J. 1997. Bootstrap confidence limits for groundfish trawl survey estimates of mean abundance. Canadian Journal of Fisheries and Aquatic Sciences (54): 616–630.
- Stanley, R.E., DiBacco, C., Lowen, B., Beiko, R., Jeffery, N., Wyngaarden, M., Bentzen, P., Brickman, D., Benestan, L., Bernatchez, L., Johnson, C., Snelgrove, P., Wang, Z., and Wringe, I., B. Bradbury. 2018. A climate-associated multispecies cryptic cline in the northwest Atlantic. Science Advances 4(3): 1–7.
- Swain, D.P., and Morin, R. 1996. [Relationships between geographic distribution and abundance of American plaice \(*Hippoglossoides platessoides*\) in the southern Gulf of St. Lawrence](#). Canadian Journal of Fisheries and Aquatic Sciences 53(1): 106–119.

Swain, D.P., and Sinclair, A.F. 1994. Fish distribution and catchability: What is the appropriate measure of distribution? Canadian Journal of Fisheries and Aquatic Sciences 51(5): 1046–1054.

Tremblay, M.J., Black, G.A.P., and Branton, R. 2007. The distribution of common decapod crustaceans and other invertebrates recorded in annual ecosystem surveys of the scotian shelf 1999-2006, by the research vessel groundfish survey. Can. Tech. Rep. Fish. Aquat. Sci. 74.

Ward-Paige, C.A., and Bundy, A. 2015. [Mapping Biodiversity on the Scotian Shelf and in the Bay of Fundy](#). Can. Tech. Rep. Fish. Aquat. Sci. 3068: vi + 38 p.

Wickham, H. 2019. Tidyverse: Easily install and load the 'tidyverse'. R package version 1.3.0
<https://cran.r-project.org/web/packages/tidyverse/index.html>.

Zisserson, B.M., Cameron, B.J., Glass, A.C., and Choi, J.S. 2019. [Assessment of Scotian Shelf Snow Crab in 2017](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2018/051. ix + 147 p.

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